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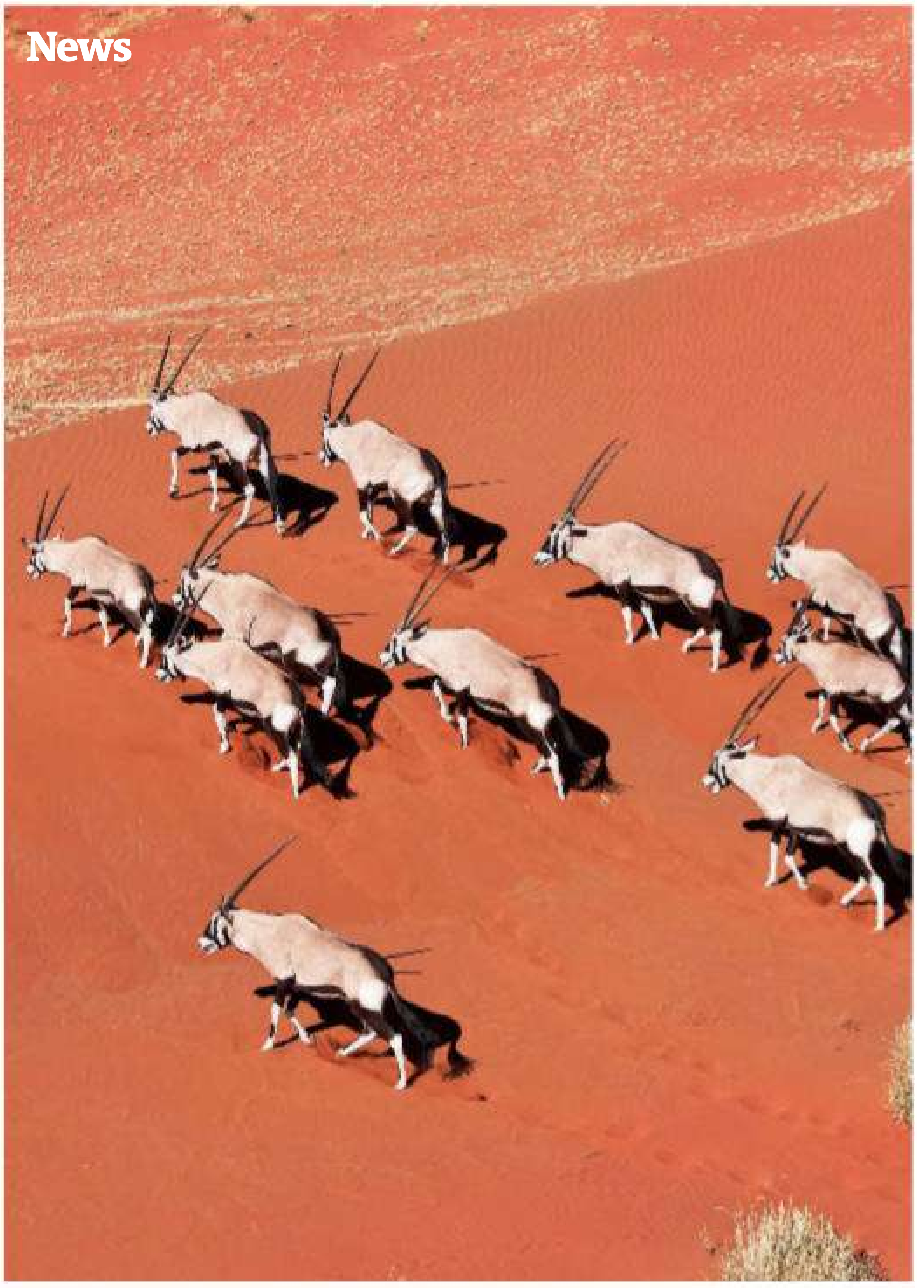

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Podcast

Weekly

The team find out why a major idea about consciousness has been dubbed "pseudoscience". And weird things are going on with dwarf planets in our solar system. Plus, a reverse vaccine to reset your immune system.

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Newsletter

Fix the Planet

Low-emissions jet fuel made from captured carbon dioxide and green hydrogen is being scaled up by companies around the world. But it uses up vast amounts of clean energy, finds James Dinneen.

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Tour

Science of the Arctic: Svalbard, Norway

Join *New Scientist*'s Rowan Hooper aboard a luxury expedition vessel. Watch polar bears and beluga whales. This 13-day tour starts on 18 June 2024 and costs £9995.

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Video

Astro photo awards

Competition judge Edward Bloomer tells us his highlights from this year's Astronomy Photographer of the Year awards, including the winning photo of a hidden region next to the Andromeda galaxy.

youtube.com/ newscientist

A note from the team

Dear readers,

The biggest annual buzz in the *New Scientist* office doesn't come when staff dig out their Christmas sweaters, or even when the Nobel prizes are announced – although both do, of course, arouse our excitement – it arrives with the advent of New Scientist Live.

We are now just a week away from our massive annual show at ExCeL London and the frisson in the air here is palpable. Every year the show has run since its launch in 2016, we have tweaked the set-up based on feedback of what people enjoyed, trying to make the event ever better.

This year, to really cover the gamut of cutting-edge science, we have five main stages: the Universe Stage, the Mind & Body Stage, the Our Planet Stage, the Future Stage and the Engage Stage. These will host a captivating range of talks from top scientists, technologists, broadcasters and entertainers, including Jim Al-Khalili, Maddie Moate, Alice Roberts, Alom Shaha and Chris van Tulleken. Do check out the full programme at newscientist.com/nslmag, but hurry, because limited tickets remain.

Across the rest of the exhibition floor, we have a huge array of art, entertainment and exhibitors, allowing visitors to marvel at robots, strange insects and a giant model of Mars, have a go at flintknapping, discover the future of farming or try out some of the latest virtual reality experiences.

All this is only part of why we get so excited. We believe science is our best tool for understanding the universe, our place in it and how we can change our health and lives for the better and protect the planet. We try to spread our sense of wonder to the rest of the world. Yet once our articles, videos or podcasts are published, we often have little idea how individuals are reacting.

At New Scientist Live, it feels very different. We have the opportunity to meet many of the people who read *New Scientist*, to watch the first time the penny drops for a small child that science can be fun, to see someone delighted that they have grasped a key concept of quantum physics, programmed a robot for the first time or discovered a healthier way to live. It is one of the reasons we have introduced the Subscriber Lounge this year, a dedicated space for *New Scientist* subscribers to relax, connect and meet our team. That connection feels vital to us all, so we hope to see as many of you at the show as possible.

Chris Simms
New Scientist assistant news editor

JONNY DONOVAN

Anthropologist Alice Roberts returns to New Scientist Live this year to give a history of Britain through burials

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The anatomy of choice

Biologists approaching the question of free will must keep a clear head

DID you freely choose to read this or was your decision predetermined? The question of whether we truly have free will is one of the oldest and most contentious of all. It certainly feels like we do, so it might also strike you as the worst kind of "armchair philosophy" – an abstract intellectual pursuit, far removed from anything to do with real life.

However, the question has echoed down the centuries not only because it is an existential one, but also because it impinges on how we think about moral responsibility: if the freedom to choose our actions is an illusion, then there is no justification to reward or punish us for them.

The standard argument against the idea that we have the capacity for deliberate, conscious decision-making is simply that the deterministic laws of classical physics rule it out.

But our thoughts and decisions appear to arise from the mind. The question then becomes whether the human brain, in all its complexity, can be reduced to the laws of physics. Who better, then, to take a fresh look at the conundrum of free will than biologists. In framing the question as one of psychology and neurology, rather than physics, they can apply a different set of tools – genetics, neuroscience and evolutionary biology – to put free will to the test, as we explore in our cover story on page 32.

> "Can the human brain, in all its complexity, be reduced to the laws of physics?"

This new approach is welcome. Yet biologists should be wary of a common pitfall for those who take on this challenge, namely the temptation to seek out evidence that supports pre-existing views informed by the moral implications of one answer or another.

The idea that we must have free will or else we would be forced to abandon our long-standing code of ethics, for example, doesn't make for a good scientific case.

Instead, given the importance of the free will question to our understanding of the human condition, we must pursue an evidence-based perspective, regardless of its consequences. In that sense, at least, we surely have the power to choose. ■

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UNIVERSITY OF MARYLAND SCHOOL OF MEDICINE

Medicine

Pig-to-human heart transplant

Surgeons have transplanted a genetically modified pig heart into a human for only the second time. Lawrence Faucette, a 58-year-old man with terminal heart disease, received the transplanted heart at the University of Maryland Medical Center on 20 September. The medical team reports he is breathing on his own, and his new heart is functioning without any mechanical support.

New Scientist Live
What meteorites reveal about our solar system
Hear Tim Gregory take us back through time on 7 October
newscientist.com/nslmag

Space

Asteroid haul returns to Earth

NASA's OSIRIS-REx mission has brought back materials from asteroid Bennu that could help us understand how the solar system formed, report **Leah Crane** and **Alex Wilkins**

SAMPLES from the asteroid Bennu have been successfully retrieved by NASA, after a capsule containing about 250 grams of the space rock touched down in the desert near Salt Lake City, Utah, on 24 September. Scientists hope that Bennu, which is older than Earth, could help explain how the solar system formed.

The capsule has been making its way home since 2020, when NASA's OSIRIS-REx spacecraft extracted samples from the asteroid. The final, riskiest part of the mission involved the capsule's controlled freefall through Earth's atmosphere, following its release by OSIRIS-Rex at about a third of the distance between Earth and the moon.

> **"Studying these organic molecules might help us understand what could have seeded life on Earth"**

Reaching speeds of 44,500 kilometres per hour, the capsule used its heat shields and two parachutes to protect its cargo and control its descent towards the ground, touching down at a leisurely 18 kilometres per hour.

"Boy, did we stick that landing," said OSIRIS-REx's principal investigator Dante Lauretta in a press conference. "It was just sitting right there, a few tens of feet right off a nice road, a perfect place for the helicopters to land. It didn't move, it didn't roll, it didn't bounce, it just made a tiny little divot in the Utah soil."

Within 90 minutes of the landing, NASA located the capsule and helicopters transported it to a makeshift clean room in a military hangar, where scientists injected a continuous flow of nitrogen into the container to keep the sample free of contaminants from Earth.

OSIRIS-REx's sample-return capsule landed safely in Utah on 24 September

NASA/KEEGAN BARBER

On 25 September, the capsule made its way by plane to NASA's Johnson Space Center in Houston, Texas, where researchers will carefully prise apart the canister and categorise the sample inside. Once the rocks have been weighed and inventoried, they will be given to research groups around the world to investigate further.

OSIRIS-REx launched in 2016 and entered orbit around Bennu in 2018. Scientists chose Bennu as a target primarily because it is relatively close to Earth – at the time of launch, it was about 225 million kilometres away, and in the intervening years it got as near as 50 million kilometres away.

Because of its regular close approaches, Bennu is classified as a near-Earth object. It isn't expected to smash into our planet any time soon, but there is about a 0.057 per cent chance of a collision in the next 300 years. Bennu is some 490 metres across, so if it did hit Earth, it could cause significant damage.

By understanding the asteroid's makeup, scientists hope that it will be easier to divert it with an impact strike, similar to NASA's DART mission, if needed.

Another reason it is of interest is that it is one of the most primitive known space rocks. "Asteroids like Bennu are time capsules from the early solar system," says Anjani Polit at the University of Arizona, who is part of the OSIRIS-REx team. Such asteroids probably clustered together to form our solar system's planets.

Bennu, in particular, hosts large concentrations of carbon, the main ingredient of organic molecules, which in turn are the building blocks for life as we know it.

"We're pretty sure that there will be organic molecules in these samples," says OSIRIS-REx scientist Michelle Thompson at Purdue University in Indiana. "Studying these organic molecules might help us understand what organics were around in the early solar system that could have seeded life on Earth."

Similar samples have been returned by Japan's Hayabusa 2 spacecraft, which visited an asteroid called Ryugu.

Having material from more than one asteroid should help us understand what was around 4.5 billion years ago when the solar system formed, says Thompson. "I honestly feel like a kid on Christmas Eve," she says. "I'm about to wake up and get all these gifts of samples from Bennu." ▮

Psyche mission also aims for an asteroid

As one mission comes to an end, another is about to start. NASA is scheduled to launch its Psyche mission to an asteroid – also called Psyche – on 5 October.

The target asteroid is less than 300 kilometres across and takes about five Earth years to complete an orbit around the sun, and the closest it gets to us is about three times the distance between our planet and Mars. If all goes well with the launch, the spacecraft is expected to arrive at Psyche in 2029.

We know almost nothing about Psyche's surface, its origins or even its composition. What we do know is that it is probably almost all metal, most of which is likely to be iron. Metallic objects like Psyche could be a key ingredient in the formation of rocky worlds like our own. Earth and other terrestrial planets have iron cores, but we have never been able to study one in detail because they are so deep underground. The mission may be our first chance to see a planetary core directly. LC

Earth science

Nearly all mammals will go extinct in 250 million years

Michael Le Page

ALMOST all land mammals on Earth will die out in 250 million years, according to computer modelling of how the planet's continents and climate will change in the very long term.

If anything resembling humans still exists on Earth at that time, they could survive with the help of technology, says Alexander Farnsworth at the University of Bristol, UK, but the planet would be much more inhospitable. "You'd hope that we'd be a space-faring civilisation by that point," he says.

This future doom is nothing to do with the human-driven climate change we face today. Instead, it is an extrapolation of two very long-term trends. The first is that the sun is gradually getting hotter. In 250 million years, the amount of heat reaching Earth's surface will be about 2.5 per cent higher.

Second, all the continents will probably come together to form a single large one straddling the equator, called Pangaea Ultima in a reference to the similar supercontinent that existed at the time of the dinosaurs. The temperatures in the interior of such a large land mass will be extreme, and there will probably be no land near the poles to provide cool refuges.

As a result of these two trends, carbon dioxide levels in the air are likely to climb. On scales of millions of years, the amount of CO_2 in the atmosphere depends on the balance between emissions of this gas from volcanoes and its removal by chemical reactions with newly exposed rocks. In the dry interior of the supercontinent, less CO_2 will react with rocks. "It's a triple whammy," says Farnsworth.

He and his colleagues used a geochemical model to calculate what future CO_2 levels might be like when Pangaea Ultima forms, and then plugged these values into a climate model. They found that in almost all scenarios, conditions in the vast majority of the supercontinent would exceed the upper limits of survivability for mammals, such as a wet bulb temperature of 35°C (95°F) – a value that reflects conditions in which they can no longer cool naturally to prevent dangerous overheating, for example by sweating (*Nature Geoscience*, doi.org/kvm2).

> "It is possible dinosaurs will once again take over the world, but it may be too hot even for them"

"We do have this upper limit with our core body temperatures that we're not very easily able to increase," says Farnsworth. During past warm periods, land mammals adapted by, for instance, evolving smaller bodies that can lose heat more easily, but the upper limit didn't change.

Some land mammals might cling on around the edges of Pangaea Ultima, yet the extreme weather in these places would make life tough, says Farnsworth. "You might still get some which can still survive this, but whether they come out as the dominant species again is a very open question."

Birds would have a better chance, he says. Many migrate long distances and their higher body temperatures of around 41°C (106°F) means their upper limit is higher. In fact, it was recently found that the body temperature of red-billed quelea can get as high as 48°C (118°F) without any apparent ill effects.

As birds are descended from dinosaurs, it is possible dinosaurs will once again take over the world, but it may be too hot even for them. "Maybe reptiles might come back again," says Farnsworth.

"The results look plausible," says Ravi Kopparapu at NASA Goddard Space Flight Center in Maryland, who studies the habitability of exoplanets. "Perhaps some mammals could adapt, but it would be really detrimental to many." ■

R.M. NUNES/ALAMY

The planet will be saying goodbye to scenes like this

Health

AI could diagnose sleep apnoea with cameras at home

Matthew Sparkes

AN ARTIFICIAL intelligence model can diagnose obstructive sleep apnoea with nearly 90 per cent accuracy using a night-vision camera, potentially doing away with the need for intrusive tests in specialist laboratories.

Obstructive sleep apnoea occurs when the walls of the throat relax and narrow during sleep, which has been linked to high blood pressure, type 2 diabetes and heart disease. The standard method of diagnosis involves an overnight hospital stay with as many as 20 sensors attached to various body parts.

The uncomfortable process can make people act unusually, affecting diagnoses. A one-night observation can also be inaccurate because the condition's severity can vary from night to night. "Accurate testing requires multi-night observation of natural sleep," says Hyung-Sin Kim at Seoul National University in South Korea.

Now, Kim and his colleagues have developed a method for monitoring a person suspected of having obstructive sleep apnoea with an infrared camera while they sleep. Their AI tool, called SIAction, can then diagnose the condition from the video alone. The process can be done cheaply, over many nights and potentially in a person's home.

The researchers used video clips of hundreds of people – about 6 hours per person – from three hospitals. These were annotated with the diagnosis to train the AI system to recognise visual clues of obstructive sleep apnoea, which may include gasping. The system could diagnose the condition with 88 per cent accuracy when tested on similar clips that it hadn't seen before (arXiv, doi.org/kvpx).

Cheap approaches to diagnose sleep apnoea in people's homes over many nights like this are the way forward, says Danny Eckert at Flinders University in Australia. ■

Analysis Coronavirus vaccination

Why are covid-19 booster vaccination policies so different?

In the US, officials recommend everyone over the age of 6 months gets a booster, while the UK is restricting it to older or vulnerable people, says **Grace Wade**

DAVID SHAROS/CHICAGO TRIBUNE/GETTY IMAGES

A covid-19 vaccination in Batavia, Illinois, last year

WHO should receive a covid-19 booster vaccine? As countries in the northern hemisphere prepare for winter, it is a question governments must tackle – and some are reaching very different conclusions.

The latest covid-19 vaccines are expected to bolster protection by targeting more recent variants of the coronavirus. In the US, the government has recommended that everyone aged 6 months and older should get a booster, whereas agencies in the UK and many other European nations are only permitting the most vulnerable to do so.

In the UK, that includes those who are 65 years and older, people with certain underlying health conditions and those in close contact with immunocompromised individuals, such as caregivers and healthcare workers. Germany and France have adopted similar policies.

This approach, recommended by the UK's Joint Committee on Vaccination and Immunisation, aims to prevent the most severe cases of covid-19. The committee estimates that preventing each single additional hospitalisation in people under 65 would require vaccinating far more individuals in this age group, with the disparity even greater when comparing people with and without underlying health conditions. "So, it makes sense to focus efforts on protecting those most likely to benefit," says committee member Adam Finn at the University of Bristol, UK.

Unclear price tag

The exact costs of the UK and US approaches are unclear, although vaccinating more people will obviously raise the price tag. The UK Department of Health and Social Care plans to publish details about the cost-effectiveness of the booster programme, while the US Centers for Disease Control and Prevention (CDC) estimates that it will cost more than $33,000 per year of full health saved for adults. The same figures for children aren't available.

Costs aside, the logistics involved in providing universal boosters would also strain the UK's healthcare systems, delaying care for other conditions, says Amitava Banerjee at University College London. Plus, models posit that more than 90 per cent of the country's population has antibodies against the coronavirus, suggesting that most people already have some protection. Booster shots would then offer minimal benefit to those least vulnerable.

$33,000

Cost of vaccination per year of full health saved for US adults

84%

Vaccination may lower the odds of getting long covid by this much

>90%

People in the UK thought to have antibodies against coronavirus

The trouble is, we can't predict whether previous immunity will protect against new variants. Immunity also starts waning six months to a year after vaccination, says Banerjee.

That is one reason why the US decided to recommend universal use of the updated booster despite most estimates indicating that doing so isn't cost-effective.

In fact, the CDC found that such vaccination will only save money across all age groups in scenarios where covid-19 cases significantly ramp up, to the point that hospitalisation rates quadruple. Similar figures aren't available for the UK.

"Children and adults with no underlying conditions still experience severe covid-19 illness," says a CDC spokesperson. For example, in the US, half of those aged 17 and younger who died in hospital due to covid-19 between January 2022 and June 2023 had no underlying health conditions. Meanwhile, the same was true for 13 per cent of 18 to 49-year-olds admitted to a hospital intensive care unit for covid-19. "The CDC is making the recommendation to protect the greatest number of people possible," says the spokesperson.

Long covid protection

Universal vaccination also continues to safeguard against long covid, which often affects people without a severe initial infection, says Banerjee. Research suggests that vaccination may lower the odds of developing long covid by up to 84 per cent. "That's another rationale for having vaccination for people who aren't necessarily going to be admitted [to hospital]," he says.

The divergent approaches to covid-19 vaccination in the US and UK come down to differing views on costs, risks and benefits. In the UK, health services are already stretched, facing everything from unprecedented strikes to hospitals beset by unsafe building materials. In those conditions, it is perhaps no surprise the country is taking a more limited approach. Meanwhile, in the US, an abundance of caution prevails. "It is kind of a better-safe-than-sorry argument," says Banerjee.

Ultimately, existing immunity rates and the relatively low prevalence of covid-19 mean that the difference between the two approaches will probably be marginal at the population level. For individuals, though, there are still risks to not getting vaccinated, regardless of health status. That is why some people have called for the UK government to allow private purchase of the updated boosters.

"Vaccines are ultimately subject to individual choice," says Finn. "If a vaccine is offered by the state, individuals can refuse them. Conversely, if it is not offered, individuals who nevertheless want them should be able to obtain them." ▮

Technology

Squeezing loofahs creates electricity for powering LEDs

Matthew Sparkes

LOOFAH sponges – the porous husks left after drying the fruit of luffa plants – can create enough electricity when squeezed to power LEDs. This could lead to green and cheap power supplies for small devices.

Many electrically insulating materials can create an electric charge when their structure is deformed – a phenomenon called piezoelectricity – but the size of that charge is usually vanishingly small.

Jianxiang Wang at Peking University in Beijing, China, and his colleagues have now investigated whether the loofah material often used in the kitchen or shower could do better.

The researchers chemically treated the dried sponge to remove lignin and hemicellulose, two of the polymers that make up its structure, leaving behind only a cellulose crystal form. When a 6-millimetre-thick section of this sponge was squashed by hand, it generated up to 8 nanoamps of electricity. Placed into an electrical circuit with capacitors that could store the power of many squashes, it was able to briefly power six LED lights (*PNAS*, doi.org/kvpc).

Andrew Bell at the University of Leeds, UK, says the ratio of electrical power to mechanical input from squeezing is smaller than with other piezoelectric materials such as lead zirconate titanate, which makes it of limited practical use in itself. “I will not be buying shares in luffa plantations any time soon,” he says.

Wang says loofahs might show us an environmentally friendly and cost-effective way to make small power sources, but it may be that the natural material ends up inspiring an artificial alternative that is easier to produce. “To charge a mobile phone, we’d need a bigger chunk of loofah sponge, which may not be very practical at present,” he says. ▮

Neuroscience

Man who sees upside down gives clues on how we process faces

Grace Wade

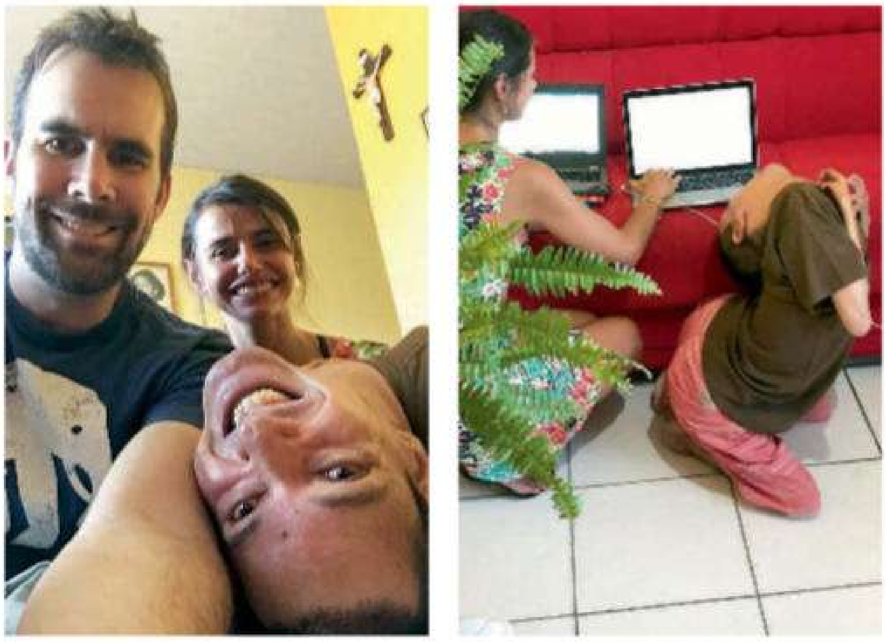
CLAUDIO OLIVEIRA, a 42-year-old whose head has been in an upside-down orientation since birth because of a medical condition, has provided us with new insights into the way the human brain processes faces. Unlike most people, he shows similar levels of accuracy when asked to identify faces in images regardless of whether they are shown upright or are inverted. This hints that facial recognition is affected by experiential as well as evolutionary factors.

Humans are typically worse at processing information in faces that are presented upside down rather than right-side up. This phenomenon is known as the face inversion effect. “This affects almost every aspect of face perception – identity, reading people’s facial expressions, deciding whether somebody’s attractive,” says Brad Duchaine at Dartmouth College in New Hampshire.

Why humans are often better with upright faces than inverted ones is unclear. One idea says it is because we are exposed to more upright faces in our lives. Another is that our visual system has evolved to process faces with the same orientation as ours. To see which is correct, Duchaine and his colleagues worked with Oliveira and 22 people who typically hold their heads upright to test facial perception skills.

Oliveira was born with a joint condition called arthrogryposis multiplex congenita, which restricts range of motion in multiple joints. As a result, fixed joints in his neck have left his head permanently rotated backwards between his shoulder blades, causing most faces he encounters to be held in a mismatched orientation to his. However, this hasn’t stopped him reading, writing or navigating the world; he works as a tax accountant.

The researchers wanted to know if Oliveira identifies upright faces better than inverted ones. If so, it would suggest that facial perception is based on experience. If, however, he identifies inverted faces most easily, it would offer evidence that facial perception skills arise from an evolved mechanism that allows us to better process faces in the same orientation as our own.



Claudio Oliveira’s condition restricts the movement of his neck

RAD DUCHAINE

> **“Most faces Oliveira encounters are held in a mismatched orientation to his”**

Their experiments showed that, regardless of their orientation, Oliveira identifies faces with broadly similar levels of accuracy. Study participants were asked to determine whether two images – one side profile and one showing the full face – showed the same person. Oliveira answered correctly 61 per cent of the time when shown upright faces and 68 per cent of the time with inverted ones. The control group’s accuracy was, on average, 83 per cent for upright faces and 64 per cent for inverted ones (*iScience*, doi.org/kvk2).

Oliveira’s comparable accuracy with upright and inverted faces supports the idea that both evolutionary and experiential factors drive facial perception, say the researchers.

“There are a lot of people who have face processing deficits due to developmental factors,” says Duchaine. Many autistic people, for instance, struggle to process faces. Duchaine says understanding the mechanisms behind these skills may lead to new ways of reducing or treating problems in facial processing. ▮

New Scientist Live
How mind, body and society shape disability
See Suzanne O’Sullivan speak on 7 October
newscientist.com/nslmag

New Scientist Live
Jupiter and the JUICE mission
See mission scientist Michele Dougherty on 8 October
newscientist.com/nslmag

Space exploration

The best place to build a moon base

Lots of sunlight and shade will provide lunar station inhabitants with solar power and water

Alex Wilkins

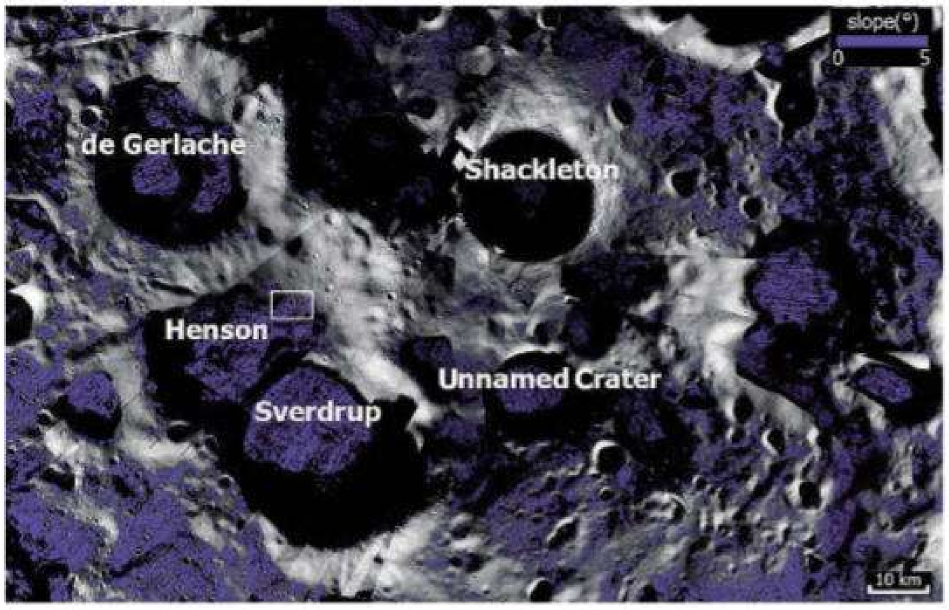
AN AREA within a pair of craters at the moon's south pole is the perfect location for a lunar base, thanks to a relatively plentiful water supply and gentle slope, researchers have determined.

The south pole has long been considered a good place for settlement because its many craters experience both permanent sunlight and shade, making it possible to generate electricity using solar panels while also having icy zones to mine for water. The areas around some of the craters have been explored by lunar rovers, like India's recent Chandrayaan-3 mission.

There have been some proposals for specific settlement spots at the south pole based on the amount of sunlight they get, such as at Malapert Massif, which is in a crater at the edge of the pole, or the Shackleton crater, but crucial information on how much ice and other resources are available wasn't included.

"Now, we have a place," says Giovanni Leone at the University of Atacama in Chile. He and his team gathered all the existing data on the distribution of water ice, slope angles and the amount of sunlight that falls on five of the moon's southern craters and ranked them. They then decided on a list of the most important criteria, such as the amount of frozen water and carbon dioxide, potential power sources, ease of access and sites suitable for communication links with Earth.

The plot near Henson crater thought to have the right amenities for a moon base



GIOVANNI LEONE ET AL. 2023

The top-rated place was an area of about 5 square kilometres within a pair of linked craters, known collectively as Sverdrup-Henson. The surface is relatively flat, making building and travel easier, and ice and minerals exist in nearby shaded zones. There are also areas of permanent sunlight, for power generation, and spots for communication links to Earth (*iScience*, doi.org/kvmf). "It's a trade-off between the water within reach and, at the same time, the base must be in light to have some energy," says Leone. "There is a possibility to expand all around, given that there is direct access in and out of these [Sverdrup-Henson] craters."

There is still some uncertainty in the data on the craters, says Leone, and it is unclear whether there will be enough water available even in these areas that are fairly rich in ice.

The work takes into account a good amount of data and is relatively up to date, says Simeon Barber at the Open University, UK, but much of the data is from remote instruments and might not be fully accurate. "There are lots of ideas for where to build a lunar base. I think the real answers will come when we get more ground truth measurements," he says.

Upcoming missions on the moon's surface, like NASA's VIPER robot, due to land next year, should tell us more about the distribution of resources such as water and carbon dioxide. They can also tell us how difficult different regions are to drive around in, which might end up being crucial, says Barber. ▮

Mental health

Therapy dogs in classrooms may boost well-being

THE use of therapy dogs in schools may improve children's mental health, encourage learning and help them fit in with their peers.

Many students struggle with learning, behavioural or emotional difficulties at school, and some experience bullying. These issues can reduce well-being and have long-term consequences, says Robert Baird at Monash University in Melbourne, Australia, with some students going on to experience mental illness, substance abuse, social isolation and job insecurity.

Because these students tend to disengage from school, they often get little benefit from standard interventions like psychological support or anti-bullying schemes.

To investigate if bringing therapy dogs into classrooms may offer a good alternative, Baird and his colleagues turned to 118 teachers, principals, school mental health professionals and related experts with experience of therapy dogs in classrooms with age groups ranging from 5 to 18 years old. The respondents completed a survey, mainly about the dogs' effects on students' mental health.

The educators generally considered the dogs' presence beneficial in a variety of circumstances. For example, some reported that the dogs motivate students to interact with their peers, develop friendships and learn social norms, as well as helping them learn to regulate their emotions.

> "As 'non-judgemental companions', therapy dogs can also help overcome certain effects of bullying"

Children with reading difficulties also gain confidence by reading out loud to dogs, whom they trust to not judge them (*Journal of Veterinary Behavior*, doi.org/kvpv). "Being with a dog is a major incentive to engage," says Baird. As "non-judgemental companions", therapy dogs can also help overcome certain effects of bullying, he says.

The study confirms previous findings about the advantages of such schemes, says Laura Bassette at Ball State University in Indiana, helping children to improve their confidence and motivation. ▮

Christa Lesté-Lasserre

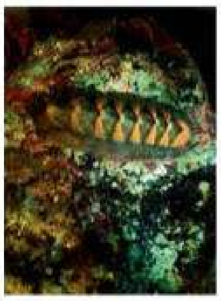
Marine biology

Armour-plated mollusc may fluoresce to hide

Jake Buehler

THE shells of chitons fluoresce a rich red-pink colour under blue light. This vibrant display may help the animals hide from predators.

The flat molluscs, which are common in tidal pools, are an ancient branch of the mollusc family tree. Unlike their snail and clam relatives, chitons' shells are made of a series of eight plates running along their backs.



A chiton (*Iscnhoplax pectinata*) fluorescing

GUIDO GRIMALDI

To investigate if chitons can hide by using their ability to absorb light and re-emit it in a different colour, known as biofluorescence, Guido Grimaldi at the Federal University of Santa Catarina in Brazil and his colleagues collected 44 chitons (*Ischnoplax pectinata*) from underneath intertidal boulders near Natal, Brazil. When they put the chitons under blue light in the lab, the animals' back plates reflected an intense red-magenta. "It was amazing," says Grimaldi.

The colour closely matched the fluorescent shades produced by red algae in the chitons' habitat. Data on the sensitivity of the eyes of predators like crabs, fish and gulls to a range of wavelengths suggests that these animals would find it hard to see the chitons against the background of algae, say the researchers (bioRxiv, doi.org/kvkm).

But Daniel Speiser at the University of South Carolina isn't convinced the blue light used in the experiment adequately represents natural conditions. The team has "documented an interesting natural phenomenon, but not one that is ecologically meaningful", he says. ▮

Analysis Climate targets

Net zero delay wastes time the UK doesn't have

The British prime minister's decision to push back plans for cutting emissions will make it hard to hit targets, says **Michael Le Page**

UK PRIME minister Rishi Sunak has said that he will weaken some of the country's key plans for achieving net-zero emissions by 2050. Arguing that the UK has "massively over-delivered" on its carbon targets, Sunak called for a "more pragmatic, proportionate and realistic approach to reaching net zero".

"We've stumbled into a consensus about the future of our country that no one seems to be happy with," he said at a press conference on 20 September.

The UK's existing plans for net zero included a ban on the sale of new cars that run only on petrol or diesel from 2030, the phase-out of gas boilers from 2035 and a requirement for new homes that can't be connected to the gas grid to install non-fossil fuel heating from 2026. These plans will now be delayed and weakened, Sunak announced. "It should be you, the consumer, that makes that choice, not government forcing you to do it," he said.

Sunak appears to have taken issue with the way climate plans have been made in the UK since 2008, when the Climate Change Act committed the country to reducing its greenhouse gas emissions by 80 per cent relative to 1990. In 2019, the target was changed to 100 per cent, or net-zero emissions.

Rishi Sunak speaking about a delay to net-zero policies on 20 September

SIMON WALKER/NO 10 DOWNING STREET

Under the act, the UK must meet various intermediate targets, sometimes called carbon budgets, for cutting emissions. Sunak said there had been a lack of parliamentary scrutiny for these targets, adding "we can never allow carbon budgets to be set in the same way again".

Off target

Yet the UK isn't on track to achieve these goals. An independent body called the Climate Change Committee (CCC) is responsible for advising the UK government and monitoring progress. According to the committee, back in 2019, the UK wasn't even on track to meet its 80 per cent target.

The latest progress report from the CCC, published in June, was also highly critical. "Our response to the recent fossil fuel price crisis did not embrace the rapid steps that could have been taken to reduce energy demand and grow renewable generation," the report said. "We have backtracked on fossil fuel commitments, with the consenting of a new coal mine and support for new UK oil and gas production."

2050

Target year for when the UK should hit net-zero emissions

The UK might meet its intermediate target for the 2020s, but it isn't on course to achieve its goal for the 2030s, according to the CCC report. It called for urgent action and said the government should stay "firm on existing commitments and move to delivery".

But Sunak is doing exactly the opposite, delaying action and weakening commitments. Among other things, this move will dent the confidence of investors. Many businesses were swift to condemn the decision, including the car company Ford, which before Sunak's press conference said that firms need "ambition, commitment and consistency" from the government.

The bigger problem is that, so far, the UK's emissions cuts have come from doing the relatively easy things, such as generating electricity from renewables instead of fossil fuels. The country has barely begun to tackle the harder parts, such as replacing the heating systems in homes, greening steel production and cutting emissions from farming and flying. These will all take time. With only 26 years remaining before 2050, there isn't much to waste. ▮

Simon Sharpe explains how to decarbonise five times faster on page 37

A history of Britain through burials
Hear Alice Roberts shed light on early societies on 8 October
newscientist.com/nslmag

Ancient humans

Earliest evidence of wood buildings

At a site in Zambia, there are the first tentative hints that, rather than roaming, people stayed put 476,000 years ago and built large wooden dwellings, finds **Colin Barras**

PROFESSOR GEOFF DULLER, ABERYSTWYTH UNIVERSITY

Researchers uncovering an ancient wooden structure (left) upstream of Kalambo Falls, Zambia (above)

ANCIENT humans were building large wooden structures – possibly houses – almost half a million years ago. The discovery, the earliest evidence of wooden construction, suggests that some ancient communities were far less nomadic than we have assumed.

"These people were behaving in ways I hadn't expected," says Larry Barham at the University of Liverpool, UK.

Barham and his colleagues uncovered the evidence at Kalambo Falls, an archaeological site in Zambia. In 2019, they spent a month excavating a sandbar some 300 metres upstream of the falls. One of the first artefacts they found was a wooden tool, probably a digging stick. "The number of sites where wood is preserved is small," says team member Geoff Duller at Aberystwyth University, UK.

As they continued to dig, they made another discovery: a 1.4-metre-long log overlying an even larger log that was too big to fully excavate during their month-long project. They saw that the overlying log had been worked with tools to fashion a deep notch midway along its length. This allowed it to interlock with the underlying log at a 75-degree angle, creating a relatively sturdy joint. The researchers speculate that the two interlocking logs were once part of a larger wooden structure (*Nature*, doi.org/kt9q).

Duller dated the artefacts using a technique called post-infrared infrared stimulated luminescence. This involves measuring the time since the mineral grains in the sand that surrounded the wood were last exposed to light prior to their burial. The mineral grains – and the artefacts they surround – were buried about 476,000 years ago, which implies that the wooden structure was built before our species evolved. The engineers therefore belonged to an earlier human species, possibly *Homo heidelbergensis*.

We already knew that ancient humans made use of wood. For instance, researchers have discovered 300,000-year-old wooden spears at a site in Germany, possibly made by *H. heidelbergensis*. "But those wooden implements are portable," says Barham, which fits with the prevailing idea that early humans were always on the move. The large wooden structure at Kalambo Falls suggests to Barham that at least some early humans were staying put. "They were investing in this place."

> "We might need to rethink our labelling of the Stone Age. Maybe it was more of a wood age"

"There's something really exciting about this discovery that they were constructing and [they] had a real sense of the importance of place," says Penny Bickle at the University of York, UK.

The ability to modify the local environment – sometimes called niche construction – isn't uniquely human. Plenty of other species, such as beavers, do this too, but their techniques are far less sophisticated than those used at Kalambo Falls. "To my knowledge, [non-human] animals do not use tools to modify materials to create structures," says Annemieke Milks at the University of Reading, UK.

The engineers at Kalambo Falls needed to produce sharp-edged stone tools from rocks, recognise they could use those tools to cut through wood and then work in groups to transport and modify that wood to produce a large structure. "It involved a lot of planning, and I do think language was involved," says Barham.

However, it is difficult to say what sort of wooden structure the logs once belonged to. Barham speculates it might have been a dwelling or maybe a walkway raised above the wet floodplain designed to keep early humans and their food dry.

Manuel Domínguez-Rodrigo at Rice University in Texas says that, while it may have been a structure or shelter, we can't read too much into the function of just two pieces of wood.

In an accompanying opinion article, Milks says the finding shows "when people started to structurally alter the planet for their own benefit", arguably drawing a line between Kalambo Falls and today's highly modified human environments (*Nature*, doi.org/kt9r).

But Barham thinks the story is more complicated. He says there were periods after the Kalambo Falls structure was built when humans were typically more mobile, so there isn't a direct link between the apparently sedentary behaviour on show at Kalambo Falls and the sedentary human lifestyles of recent millennia.

Either way, the discovery should shift perceptions, says Barham, because it gives a rare insight into how important wood must have been to ancient humans. "We might need to rethink our labelling of the Stone Age," he says. "Maybe it was more of a wood age." ■

Mental health

Brain damage linked to schizophrenia may spread as the condition develops

Clare Wilson

THE brain changes associated with schizophrenia may start in small regions and then advance through the brain, but the mechanism behind this is a mystery.

Schizophrenia is a condition that can involve hallucinations and paranoid delusions, but its underlying cause is unknown. Previous studies have suggested it is linked with slight shrinkage of tissue in several parts of the brain. In total, those affected may have a few per cent less "grey matter", suggesting loss of brain cells or the connections between cells, called synapses.

To see if the pattern of shrinkage changes over time, Sidhant Chopra, then at Monash University in Melbourne, Australia, and his colleagues looked at brain scans from four previous studies of people with schizophrenia.

This included scans from people in the first months after diagnosis, those who had had the condition for years and those without the condition, looking at nearly 900 people in total.

The shrinkage of brain tissue seemed to start in two regions called the hippocampi, found on each side of the head, which are known for their role in memory formation. In the people who had had the condition for several years, there was also a loss of grey matter in wider regions, such as the frontal and temporal lobes of the brain, which are involved in many cognitive functions including planning and decision-making (*JAMA Psychiatry*, doi.org/kt9t).

The progression of damage over time seemed to follow the major neural routes between brain areas. "This tells us that the exact wiring pattern of the brain is important for shaping volume loss and its potential progression from the hippocampus," says Chopra.

It is unclear what causes this spread, he says. Schizophrenia isn't thought to be caused by infections, nor by a change in the folding of proteins called prions, which is another way damage can spread in the brain.

> "What we're thinking is spreading is potentially some sort of altered activation of neurons"

"What we're thinking is spreading is potentially some sort of altered activation of neurons," says Chopra. "It's a bit hand-wavy."

Another idea is that symptoms of schizophrenia are linked with the overactivity of neurons that send signals using the brain chemical dopamine, because the antipsychotic medicines that reduce symptoms also lower levels of dopamine. "What we're showing here is not mutually exclusive with the dopamine signalling hypothesis," says Chopra. "Perhaps that spreading is altered dopamine signalling."

The findings also shed light on a long-standing question: whether the grey matter loss is caused by schizophrenia or is a side effect of the antipsychotic drugs taken by most people with the condition.

One group of people in the study had only just been diagnosed and hadn't yet begun taking antipsychotics, yet they already had grey matter shrinkage in their hippocampi.

Paris Lalousis at King's College London says the work may help us understand schizophrenia. "It gives us a gateway into the biological mechanisms of schizophrenia and could potentially unlock novel targets for drug development," he says. "But the precise mechanisms driving the spreading will need to be understood." ▮

Biotechnology

Genetically modified silkworms produce pure spider silk

SILKWORMS have been genetically engineered with CRISPR gene editing to produce pure spider silk. The larvae could offer a scalable way to create things like surgical thread or bulletproof vests from spider silk, which is prized for its strength, flexibility and lightness.

Farming silk from spiders is difficult because the animals tend to eat each other and only produce a small amount of silk. So, people have been trying with varying degrees of success to genetically engineer silkworms to make spider silk instead of their own silk, because silkworms are easier to farm and produce more fibre.

Spools of silk fibres produced by the gene-edited silkworms

JUNPENG MI, DONGHUA UNIVERSITY

Now, Junpeng Mi at Donghua University in China and his colleagues have used CRISPR gene editing to insert the genes for making spider silk proteins into silkworms. The resulting animals produced silk that was 100 per cent spider silk and was able to withstand a stretching force of 1299 megapascals without breaking, making it 1.3 times stronger than nylon. Its toughness – the energy it could absorb under impact – was 319 megajoules per cubic metre, six times tougher than Kevlar (*Matter*, doi.org/kt93).

The silkworms also produced a protective coating to the spider silk, like that created by spiders. This is likely to make the fibres more durable than artificially created spider silk, says Mi. "This makes silkworms an all-in-one station for spider silk fibre production," he says.

The engineered silkworms could enable cheap mass production of spider silk, which may be used as surgical suturing thread or in bulletproof vests, says Mi. The team tried using the silk as a suturing thread for stitching up incisions in rats and found that the wounds healed better than when nylon threads were used, he says. ▮

Alice Klein

New Scientist Live
Building a brain in a dish
Hear Selina Wray on the promise of stem cells on 8 October
newscientist.com/nslmag

Health

Erasing the body's immune memory

A vaccine that stops the body attacking itself could help with conditions like multiple sclerosis

Grace Wade

AN EXPERIMENTAL vaccine has reduced signs of multiple sclerosis (MS) in mice by stopping their immune systems targeting their own cells. If it works in humans, the vaccine might treat MS and other autoimmune conditions, including type 1 diabetes and coeliac disease.

Autoimmune conditions occur when a person's immune system mistakenly attacks their own cells. With MS, for example, immune cells damage the protective coating around nerves, leading to issues such as muscle spasms.

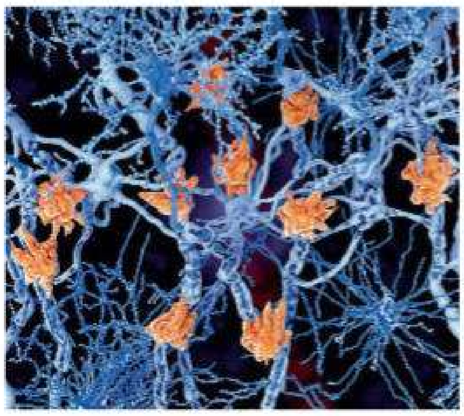

JUAN GAERTNER/SHUTTERSTOCK

Illustration of microglia cells (orange) damaging the myelin on neurons

Now, Jeffrey Hubbell at the University of Chicago and his colleagues have developed a vaccine to halt this faulty response. Whereas conventional vaccines train the immune system to identify and counteract specific molecules, their "inverse vaccine" does the opposite, unwinding a learned immune response.

It works by hijacking a system for clearing dead cells, he says. When our cells die, they develop a specific molecular pattern on their surface, like an out-of-service sign. That way, once they reach the liver, the organ recognises the cells as waste and removes them. The liver also signals to the immune system that these dead cells aren't a threat, and therefore immune cells shouldn't attack them. This inhibits any unwanted responses.

Hubbell and his team modified molecules that spur immune reactions, called antigens, by adding a structure to them that mimics this out-of-service sign. Once in the body, the liver treats this structure like a dying cell, clearing it away and informing the immune system that it, along with the accompanying antigen, isn't a threat. This teaches the immune system to ignore the antigen in the future, thus undoing an immune response, says Hubbell.

To see if the vaccine could treat autoimmunity, the researchers used it on 10 mice. The animals had previously received an injection of a single antigen that caused their immune systems to attack the protective coating of nerves, much like MS does. The vaccine targeted this molecule.

The researchers tracked symptoms in the animals using a scale of 0 to 5, with higher scores indicating greater severity. Two weeks after the mice received the vaccine, they scored, on average, less than 1. Meanwhile, an equal number of rodents given saltwater injections scored higher than 2.5, indicating that the vaccine dampened autoimmune responses. Hubbell and his team found that the vaccine was effective in non-human primates as well (*Nature Biomedical Engineering*, doi.org/gsp9xb).

A different version of the reverse vaccine is in an early-stage clinical trial for MS, says Hubbell. It remains to be seen if it can halt the condition's progression.

"It teaches the immune system to ignore an antigen, thus undoing an immune response"

"The trouble is multiple sclerosis is not caused by one antigen," says David Hafler at Yale University. "Each patient is different, and we're finding autoreactivity to a number of different antigens." As such, Hafler doesn't believe these findings will translate to humans.

Hubbell says the vaccine can be tweaked to target other antigens, so it may treat other autoimmune conditions. For instance, a similar injection showed promise against coeliac disease in a small trial. ▮

Zoology

Jellyfish learn from experience even without a brain

CARIBBEAN box jellyfish can learn, despite their lack of a central brain. The discovery sheds new light on the evolution of learning and the mechanisms behind it.

"Learning is the pinnacle of nervous system performance," says Jan Bielecki at Kiel University in Germany. Until now, researchers had generally assumed that learning from an experience and adapting a behaviour – like avoiding a hot pan after a burn – was limited to more biologically complex animals with relatively large brains, including mice, birds and primates. But some studies have hinted that simpler creatures may do this too.

To investigate learning in jellyfish, a group that represents a very early stage in animal evolution, Bielecki and his colleagues placed a fingernail-sized Caribbean box jellyfish (*Tripedalia cystophora*) in a round tank with walls that were painted with white and grey stripes to resemble the vertical mangrove roots through which the species manoeuvres in the wild.

They used grey stripes, rather than black, so that the "roots" would look further away than they were. This optical illusion initially caused the jellyfish to bump into the tank walls. But after less than 10 minutes in the tank, each of the 12 jellyfish they tested began pivoting to avoid the walls, suggesting they had learned from the collisions. By the end of the experiment, the jellies had cut their crashes in half and quadrupled their successful swerves (*Current Biology*, doi.org/kt9s).

JAN BIELECKI

Caribbean box jellyfish swim among the roots of mangroves

"Now we've shown that this very simple, very evolutionarily early animal is actually able to learn," says Bielecki. The researchers think the learning happens in the jellyfish's four visual sensory organs, called rhopalium, which are embedded throughout its body. ▮

Corryn Wetzel

Palaeontology

Prehistoric people may have made tools from human bones

Christa Lesté-Lasserre

ANCIENT farmers and herders in southern Spain buried their dead in a large cave as far back as 5900 years ago, but may have later cut them up to make tools and possibly eat their bone marrow.

Since 1934, scientists, amateur archaeologists and even tomb raiders have been exploring human skeletal remains left in a Granada cave called Cueva de los Marmoles.

Within the 2500-square-metre cave – which harboured multiple generations of bodies across three millennia – people have previously found a carefully carved human skull cup, a well-crafted tibia tool and dozens of other bone fragments. Now, evidence suggests that some remains may have been intentionally broken and scraped up to a year after the individuals died.

The findings indicate that people may have been manipulating the bones after the cadavers had decayed slowly in the cave's cool, humid environment, says researcher Marco Milella at the University of Bern in Switzerland.

Milella, his co-lead researcher Rafael Martínez Sánchez at the University of Córdoba, Spain, and their colleagues went to the cave to collect further artefacts and investigate them using modern methods, such as advanced carbon dating, and hi-tech microscopic and scanning equipment.

They examined 411 bone fragments and 57 teeth that were unearthed in various zones of the cave, some of which they borrowed from a museum. They found that the remains were from at least a dozen human adults and children living in prehistoric agricultural societies. The findings suggest that people used the cave as a burial site during three distinct periods: 3900 to 3750 BC, 2600 to 2300 BC and 1400 to 1200 BC.

The researchers also found that while 3 per cent of the fragments had been gnawed by animals, nearly a third had been intentionally broken or cut with human tools. These fractures, scrapes and slices occurred when the bones were still "fresh" – probably up to a year after death (*PLoS One*, doi.org/kt6h).

But the bones show no signs of having been forcefully separated from muscles or tendons. "This suggests that the human remains were already partially decomposed when manipulated, but with the bone still being relatively elastic," says Milella. "This, in turn, points to action not performed shortly after the death of the individuals, but at least some months after death."

Notable specimens include a skull – probably from a middle-aged man – that had been scraped with stone tools and fashioned into a bowl or cup, and a teenager's shinbone that had been broken, polished and rounded into a sort of spatula, possibly for scraping materials such as leather. Several long bones had also been fractured and their insides scraped out, suggesting the marrow had been extracted for consumption, or possibly as part of a cultural practice of "cleaning the remains", says Milella.

Lacking any evidence of violence, the remains are probably not the result of power struggles between populations, he says. His team is planning to carry out DNA research that will compare the relationships among the individuals buried in the cave. ▮

J.C. VERA RODRÍGUEZ, CC-BY 4.0

An ancient human bone found in the Cueva de los Marmoles in Spain

411

Number of bone fragments found in a Spanish cave

33%

Rough proportion of bones that had been intentionally cut

Space

Chaotic stars rule at the heart of the Milky Way

Leah Crane

THE stars that orbit close to the Milky Way's central supermassive black hole, called S-stars, are so chaotic that our best simulations of their motions fall apart in just 462 years, making it impossible to predict their locations after that.

It has always been difficult to calculate the motions of many objects orbiting near one another because of rounding errors throwing off the results by tiny amounts. To make matters worse, orbiting objects may experience chaotic motion, where even minuscule changes in their behaviour can have enormous impacts on their positions. This means it is crucial to keep the numbers in calculations as precise as possible.

Now, Simon Portegies Zwart at Leiden University in the Netherlands and his colleagues have developed an algorithm called Brutus. It runs simulations of many objects, called N-body simulations, leaving the decimals intact up to hundreds of digits. That makes its calculations precise, but also slow, leading Portegies Zwart to call it "the slowest N-body code on the planet" (*Monthly Notices of the Royal Astronomical Society*, doi.org/kt6j).

The code allowed the team to calculate how long the 27 S-stars would move predictably, and it was for a much shorter period than expected. "The galactic centre looks kind of like a bigger solar system, so I thought it would be very similar, but the timescale of the chaos turned out to be less than 500 years rather than millions of years like the solar system," says Portegies Zwart.

This is because of what the team has dubbed "punctuated chaos". Things seem calm for a long time, and then two or three S-stars get too close together, shifting their orbits. That shift pulls on the black hole, which in turn pulls on the other stars, changing their trajectories in ways that are impossible to predict. ▮

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Mind

Consciousness theory under attack

Integrated information theory is seen by some as a leading explanation for consciousness, but more than 100 neuroscientists have called it untestable, finds **Clare Wilson**

ONE of the leading theories of consciousness, known as integrated information theory, or IIT, has been branded a pseudoscience in an open letter by 124 neuroscientists, including some of the field's biggest names.

The letter, which was posted online on 15 September and has been submitted to a peer-reviewed journal, says that the most recent experimental evidence claimed to support IIT didn't, in fact, test the core ideas of the theory, and that it isn't even possible to do so.

The authors of the letter include Adrian Owen at Western University in Canada, who has demonstrated that people in a vegetative state can have awareness; Chris Frith at University College London, who led pioneering brain imaging work; and Joseph LeDoux at New York University, who studies how the brain processes fear.

The hard problem

Consciousness is one of science's deepest mysteries. It is considered so difficult to explain how physical entities like brain cells produce subjective sensory experiences, such as the sensation of seeing the colour red, that this is sometimes called "the hard problem" of science.

While the question has long been investigated by studying the brain, IIT came from considering the mathematical structure of information-processing networks and could also apply to animals or artificial intelligence.

It says that a network or system has a higher level of consciousness if it is more densely interconnected, such that the interactions between its connection points or nodes yield more information than if it is reduced to its component parts.

IIT predicts that it is theoretically possible to calculate a value for the level of consciousness, termed phi, of any network with known structure and functioning. But as the number of nodes within a network grows, the sums involved get exponentially bigger, meaning that it is practically impossible to calculate phi for the human brain – or indeed any information-processing network with more than about 10 nodes.

> **"There isn't a lot of empirical support for IIT. But that doesn't warrant calling it pseudoscience"**

Scepticism has been expressed before about whether IIT is a helpful way to think about consciousness, but the latest salvo was triggered by a presentation at the June meeting of the Association for the Scientific Study of Consciousness in New York.

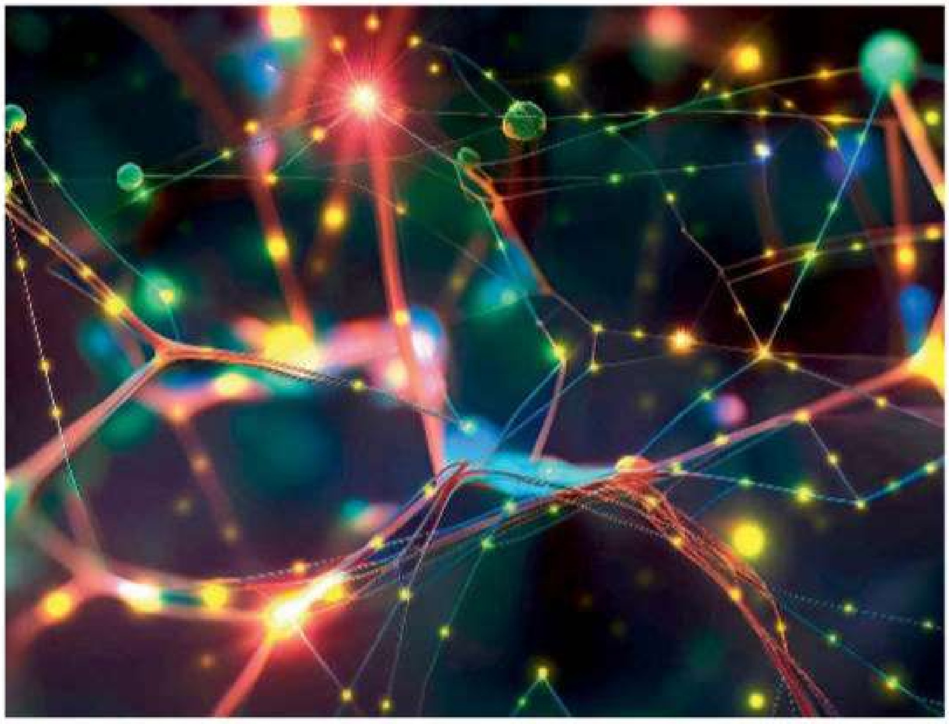
This work investigated if brain scans offered support for IIT, for instance, by looking at whether more densely connected brain regions at the back of the head – which should have a higher value of phi – had more activity when people carried out certain cognitive tasks.

The study also considered a rival theory of consciousness called global neuronal workspace theory, which says that unconscious and locally processed signals reach consciousness when they are broadcast more widely through the brain.

At the conference, the experimenters said the results offered partial support for both theories.

However, regarding IIT, the letter claims that "the studies only tested some idiosyncratic predictions made by certain theorists, which are not really logically related to the core ideas of IIT… The findings therefore do not support the claims that the theory itself was actually meaningfully tested" (PsyArXiv, doi.org/kt57).

"This [experiment] is nothing to do with the theory, and yet it was advertised as a test of the theory," says Hakwan Lau at the RIKEN Center for Brain Science in Wako, Japan, who helped organise the letter.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The interactions of brain networks somehow give rise to consciousness

Lau says some IIT supporters have overhyped these and other findings and so the public now believes IIT has more scientific support than it really does.

Animal rights

This matters, because some interpret IIT to mean that fetuses and animals have some level of consciousness, which could affect policies on abortion and animal rights, says Lau.

Giulio Tononi at the University of Wisconsin-Madison, who first developed IIT and took part in the recent testing, didn't respond to *New Scientist*'s requests for comment.

But Johannes Fahrenfort at VU Amsterdam in the Netherlands, who wasn't involved in the recent study, says the letter went too far. "There isn't a lot of empirical support for IIT. But that doesn't warrant calling it pseudoscience."

Complicating matters, there is no single definition of pseudoscience. But ITT isn't in the same league as astrology or homeopathy, says James Ladyman at the University of Bristol in the UK. "It looks like a serious attempt to understand consciousness. It doesn't make a theory pseudoscience just because some people are making exaggerated claims."

Anil Seth at the University of Sussex in the UK says: "There is valuable work going on under the banner of IIT. But there are some legitimate questions about how different theories are presented to the public." ∎

Zoology

Young birds more likely to 'divorce'

INEXPERIENCED Arctic seabird couples are the most likely in their colonies to split up, despite seeming to get no immediate benefits from doing so.

Marianne Gousy-Leblanc at McGill University, Canada, and her colleagues studied 24 years of data covering 145 breeding pairs of thick-billed murres (*Uria lomvia*) from Nunavut, Canada.

These birds usually pair for life, but the researchers found that unsuccessful breeding is the main grounds for pairs splitting up, particularly in young couples. Recoupling didn't seem to boost their chances of breeding: birds who stay with their partner succeed in fledging about 50 per cent of their chicks, but divorcees only succeed about 10 per cent of the time (*Animal Behaviour*, doi.org/kt85). **Sophie Berdugo**

Technology

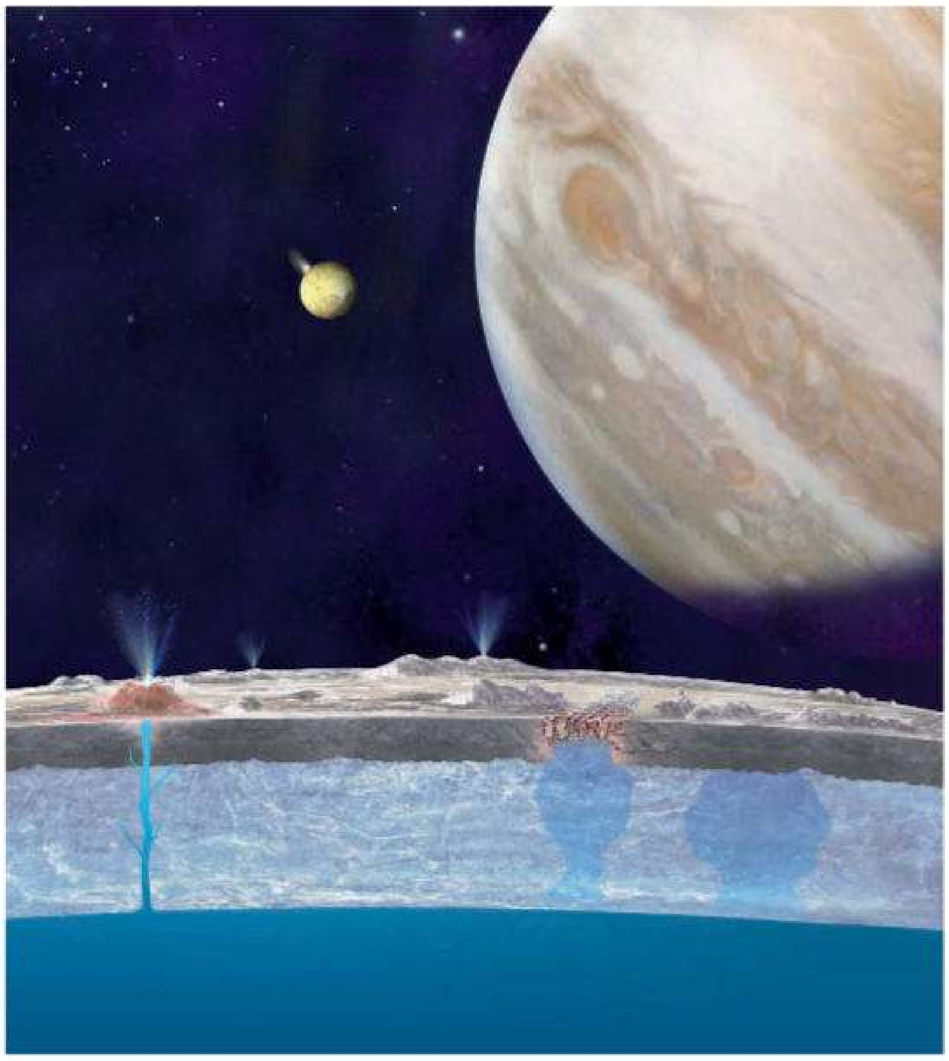
Corkscrew microbot uses sound to move

SOUND can propel a microscopic robot through liquid, which could lead to a new way of delivering drugs inside the human body.

Daniel Ahmed at the Swiss Federal Institute of Technology in Zurich and his colleagues have 3D printed a 350-micrometre-long robot that looks like a piece of corkscrew-shaped fusilli pasta.

The researchers could make it move through liquid in a spinning motion by using a device called a transducer to bathe it with sound (*Science Advances*, doi.org/gsr5b3).

This happens because the sound makes molecules in the liquid hit the robot's spirals and form vortices, propelling it. With some tweaks to the microrobot's shape and more transducers to control its path of travel, it may be able to navigate blood vessels in the body, says Ahmed.
Karmela Padavic-Callaghan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Solar system

Europa's underground ocean is leaking CO_2

THE ocean inside Jupiter's moon Europa may be carbonated – not in the sense that it is fizzy, but rather that it is full of carbon dioxide. This finding, from observations made with the James Webb Space Telescope (JWST), may be significant because carbon is an important element for life.

Two groups have analysed the observations and found the same thing: CO_2 seems to be seeping up to Europa's icy surface (see artist's rendition above). It is most abundant in an area called Tara Regio, where the ground is "chaos terrain" – a mess of pits, ridges, cracks and domes. Tara Regio is considered a relatively young area of the surface, shaped by interactions with the underground ocean over the past few million years (*Science*, doi.org/kt83; doi.org/kt84).

"That means it's highly likely that this material is new, and it has to come from the interior," says Geronimo Villanueva at NASA's Goddard Space Flight Center in Maryland. The concentrations were also raised in other areas of chaos terrain, and weren't a match to what we would expect if the CO_2 was brought to Europa by comets.

This is good for the prospect of life beneath Europa's icy shell, since all known living organisms rely on carbon as a building block for more complex organic molecules. "Carbon is a biologically crucial element, so it's important to figure out how it got to Europa, how much of it is there, and in what form it's there," says Samantha Trumbo at Cornell University in New York.

There are plans for JWST to make more viewings of Europa, which should give us a better picture of its surface, and the potential habitability of its seas. **Leah Crane**

Really brief

TAINARA SOBROZA

Monkeys shout with scent when it's noisy

Wild pied tamarins (*Saguinus bicolor*) living near cities in the Amazon rainforest use scent marking to communicate nearly twice as often as usual when noise pollution spikes from nearby towns. This doesn't affect how often they use vocal calls, though (*Ethology Ecology & Evolution*, doi.org/kt88).

Holly tree reappears after 200 years

A holly tree species in Brazil that hasn't been seen since it was first identified by Scottish naturalist George Gardner in 1838 has been rediscovered in a city almost 200 years later. Scientists found four Pernambuco holly trees (*Ilex sapiiformis*) in the city of Igarassu in north-east Brazil.

'Dark earth' stores carbon for centuries

Indigenous farmers in the Amazon make nutrient-rich, carbon-storing soil to grow crops, and archaeological evidence of this "dark earth" suggests they have been doing so for centuries. Mimicking the technique could help us store carbon to slow climate change (*Science Advances*, doi.org/gsrxxw).

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Views

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Bethan Ackerley stays up for insomnia rom-com *Still Up* p30

Comment

Laws of the wild

The rules protecting UK wildlife are riddled with outrageous omissions and egregious practices. This must change, argues **Alick Simmons**

WE TREAT our animals inconsistently in the UK – no official oversees the inhumane poisoning of wild Norway rats, for example, but step outside the law when using the same species in research and you risk prosecution.

This isn't because of any material differences, but because of tradition, prejudice and ignorance. We create arbitrary categories: farmed animals, wildlife, research animals, pets, "pests" and "game". These are perpetuated through regulations providing wildly different levels of protection and care. At one extreme, the UK has the toughest regulatory environment in the world – for animals in research – and at the other are its laws ostensibly protecting wildlife, a dog's dinner of outrageous omissions and egregious practice. This, despite growing evidence supporting a view that vertebrates and a growing number of invertebrates are sentient.

Wildlife "management" laws in the UK are riddled with indefensible exemptions. Unlike people working in slaughterhouses or technicians euthanising animals in a research facility, with very few exceptions, there is no legal requirement for anyone killing wildlife to be trained or supervised. Devices with a medieval vibe are used to trap, poison and kill. Of the few not yet proven to be inhumane, a simple description of their mode of action is enough to turn the stomach of the majority of people.

MICHELLE D'URBANO

Adding insult to injury, in the UK, much of this equipment is freely available. There is no independent inspectorate. This contrasts with research, where every investigator, premises and procedure is licensed and overseen by a powerful government inspectorate. In the US, where treatment of wildlife is similarly unaccountable, an even greater range of inhumane killing equipment is available.

What passes for wildlife management in the UK (and many other countries) falls little short of a free-for-all. But it doesn't go unnoticed. There are persistent campaigns seeking a prohibition on the use of traps and snares. This campaigning has a long history. Similar efforts driven by public revulsion led to the ban on the wanton beating of draught horses in the street and replaced the unreliable poleaxe with the captive bolt pistol to kill cattle humanely.

But why the lack of progress on wildlife? Most killing of wildlife in the UK takes place on private land given over to shooting, and those involved go to great lengths to keep it private. Of necessity, most studies of it are desktop-based or "after the event", with conclusions drawn from post-mortem examination. In short, vested interests hamper change.

Decisions involving the fate of animals are ethical and should be made on the basis of utility. That is, as well as considering "how?", it is important to consider "why?", so that, on balance, the benefits outweigh the harms. A combination of statutory ethical review and a tough regulator means animal research is well governed. In contrast, there is no independent ethical review of the reasons or the methods for killing wildlife, nor any statutory inspection. The utility of wildlife killing is also questionable when so much is done to protect non-native birds released for shooting.

In 2017, an International Expert Forum on Wildlife Control published ethical principles for wildlife management. These have been widely adopted by conservation bodies. Globally, governments have been more reticent, but recent UK laws requiring animal sentience to be considered when legislating should mean that similar principles will underpin policy.

How do we address sentience in wildlife? Start with a root-and-branch review of lethal control. Then perhaps we can treat our wildlife with a bit more respect. ▮

FRAN STOCKWELL

Alick Simmons is the UK's former deputy chief veterinary officer and author of *Treated Like Animals*

This changes everything

Alexa, speak Cheyenne

Artificial intelligence is helping keep Indigenous languages alive – but what happens when corporations get involved, asks **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Terraformers* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

LEARNING a language used to mean sitting in a classroom and memorising hundreds of words. But thanks to apps like Duolingo, you can take a quick French lesson on your phone between meetings. Or you can use Google Translate to help you read French instead. As miraculous as these apps are, they don't work for everyone – especially if you speak an Indigenous language in regions like North America or New Zealand, where European settlers made a concerted and often violent effort to replace local languages with their own.

This was something that Michael Running Wolf thought about a lot when he was working as an engineer at Amazon on Alexa, the home assistant that responds to voice commands. Now a PhD student studying natural language processing at McGill University in Canada, Running Wolf grew up in Montana on the Northern Cheyenne Indian Reservation, where he learned the Cheyenne language by talking to his grandmother. When writing code for Alexa, he realised that its speech recognition algorithms would never work for his tribe's language. That is because many North American Indigenous languages have a fundamentally different structure from English or Mandarin – two of the main languages that speech recognition software is designed for.

Many Indigenous languages in America are polysynthetic, which means that words change form depending on context. In English, we might say "the full green cup is mine", but in a polysynthetic language you could express that phrase with a single word. "There are an infinite number of words," Running Wolf explains. "Words are created on the fly and are highly contextual." Teaching Alexa to recognise these words would require a new algorithm.

But that isn't the only problem. To learn English, Alexa was trained on tens of thousands of hours of spoken English. There are no such data sets for most Indigenous languages, which might have only a few hours of recorded speech available to engineers.

The answers started to come together after Running Wolf met Keoni Mahelona at an Indigenous AI conference. Working with the Māori community, Mahelona had bootstrapped a speech-recognition model using only 310 hours of te reo, the Māori language spoken in New Zealand. Mahelona is the chief technical officer of Te Hiku Media, which runs a radio station broadcasting in te reo – making it the perfect resource for an audio data set. Now that he has shown it is possible to build a language model with only hundreds of hours of data, there is a pathway for other Indigenous languages. Mahelona is currently working with a team on Papa Reo, a platform for te reo speech-recognition apps that will make it easier for New Zealanders to speak to their devices in te reo, depending on their needs .

> **"Many Indigenous languages are polysynthetic, with a different structure from English or Mandarin"**

Running Wolf has a different goal. He wants AI that can help people practise speaking their tribes' languages. He imagines kids supplementing their school work by talking to an AI, which will recognise when they have mispronounced a word and gently correct them. He is also working with his wife, Caroline Running Wolf, a PhD student at the University of British Columbia, who is designing augmented reality (AR) experiences for people who want to learn their native languages in context. Working with members of the Kwagu'ł community on North Vancouver Island, she is creating an AR game that requires people to gather materials for a traditional potlatch feast in a virtual recreation of their ancestral lands. It is fun to steer a canoe and find ingredients while chatting in the Kwak'wala language, but it also "teaches cultural protocols", she says. "It's language in context," she adds, which is the best way to learn.

With so many Indigenous language apps on the horizon, it would seem that Alexa might soon be chatting with Running Wolf's grandmother in Cheyenne. But that is the opposite of what most Indigenous developers want. Mahelona has one message to large companies that intend to monetise Indigenous languages: "Just don't." He says they can work with Māori-run organisations like his own to access Indigenous languages through licensing or other agreements. The reasons for this go back to the days of colonisation: "Extremely wealthy corporations will profit off a language that was once beaten out of our grandparents by the government," he says. "It's another kick in the face."

Running Wolf thinks similarly. He has heard some companies have tried to get audio data on the Cheyenne reservation by offering people a few bucks to speak into a recorder. That isn't the right way to do it. "There's nothing evil in extracting data," he says, "[But] I would like a model that considers the economic development of the community." ▮

Annalee's week

What I'm reading

Deb Chachra's brilliant engineering manifesto, How Infrastructure Works.

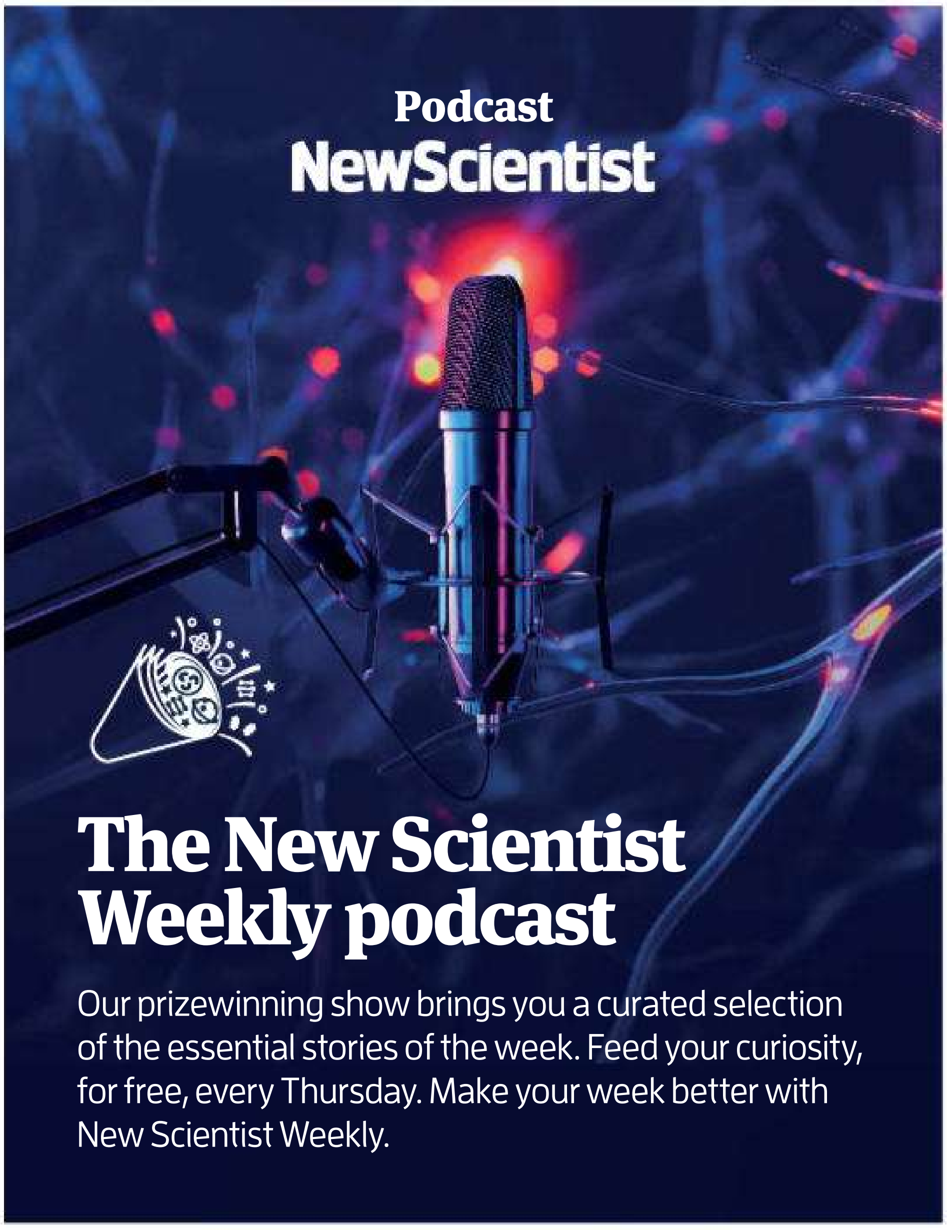
What I'm watching

The silliest, cutest pirates ever in the live-action version of the anime One Piece.

What I'm working on

Brushing up on my French in Duolingo.

This column appears monthly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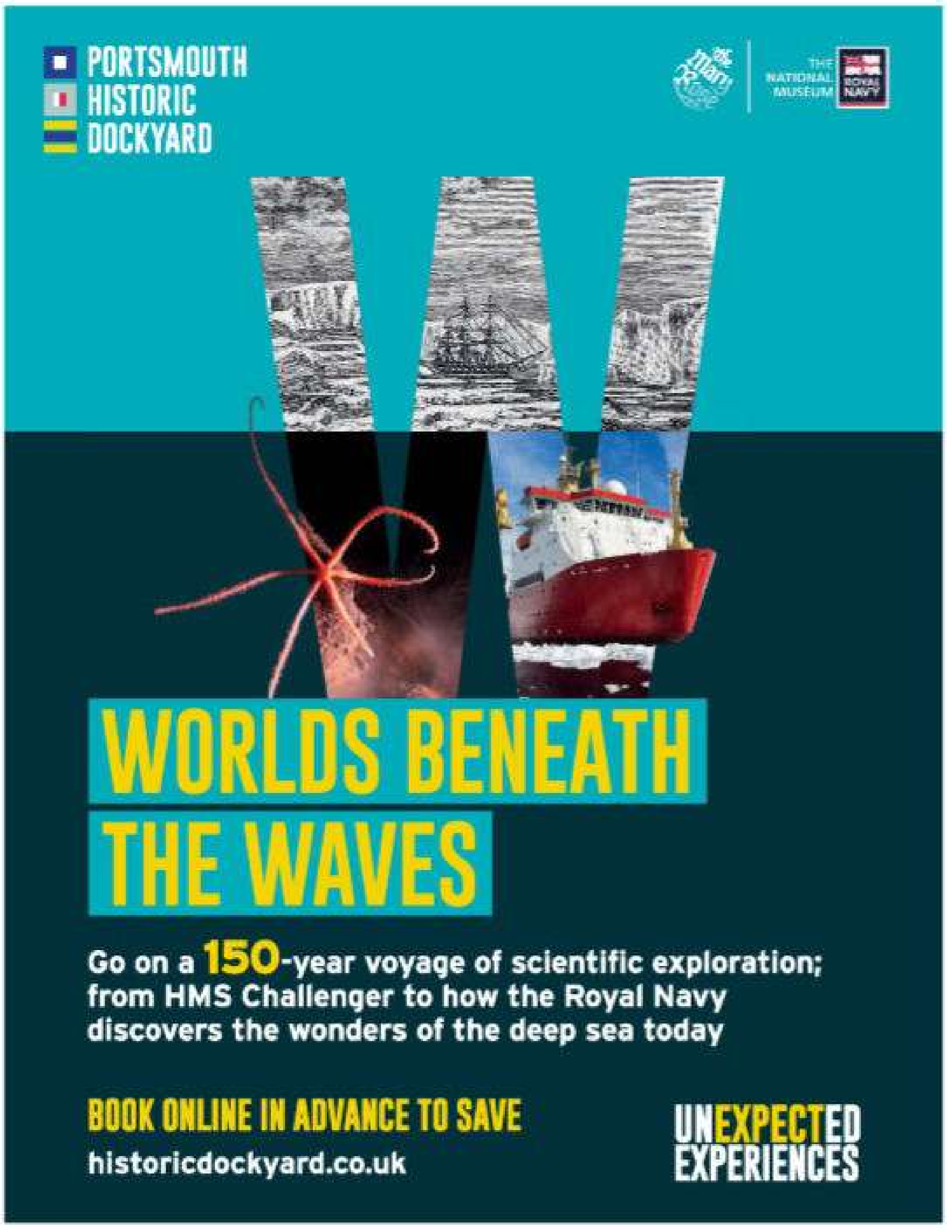
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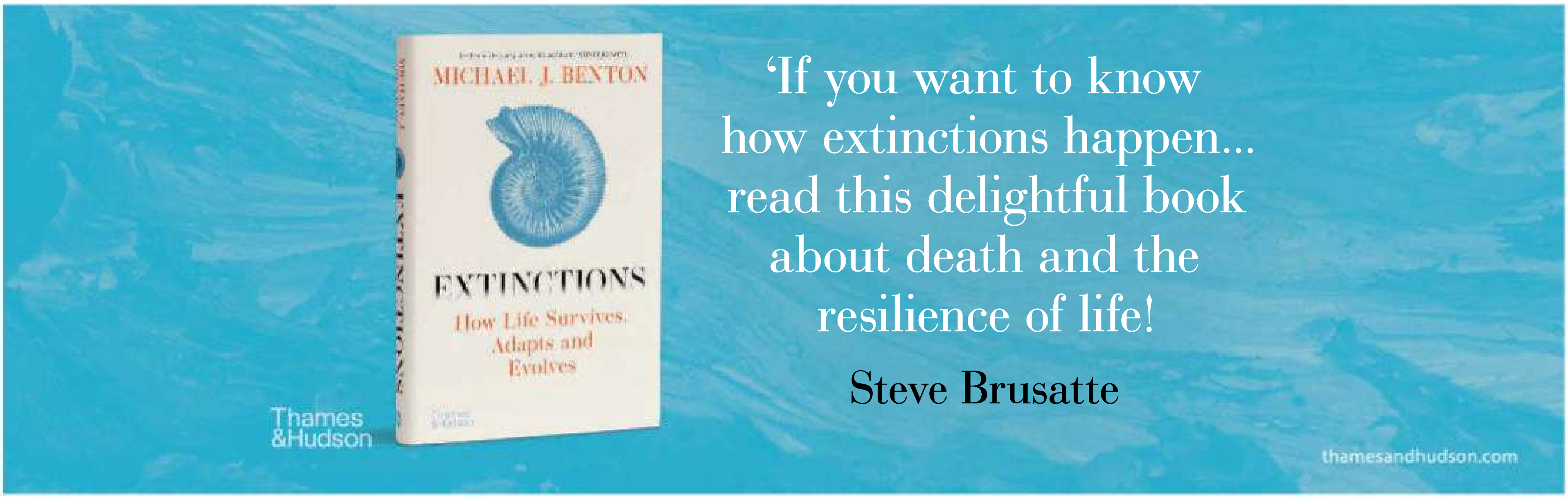
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Editor's pick

Healthy scepticism over complementary medicine

9 September, p 22

From Greg Blonder, Boston, Massachusetts, US

I share Clare Wilson's scepticism of complementary medicine, "superfoods" and magical thinking, but the World Health Organization (WHO) summit on alternative therapies was justified. Two of Western medicine's most important therapies, vaccines and analgesics, were first discovered by traditional healers. We shouldn't pre-emptively reject these treatments, even if most of them lack efficacy.

However, in parallel, we must educate the public to be more cautious and to avoid conflating "natural" with safe and effective. The WHO should offer even-handed guidance.

Summon the turtles in the fight for clean rivers

12 August, p 36

From Jonathan Spencer, Winchester, Hampshire, UK; Justin Gerlach, Cambridge, UK; and Harvey Tweats, Trentham, Staffordshire, UK

With rivers polluted by sewage, frequent drought amid climate change, associated fish deaths, organic waste and low oxygen levels all adding to the woes facing UK rivers and other water bodies, natural measures to address the worst impacts are surely going to become of increasing importance.

The argument for beavers in ameliorating water flows and creating cleaner water is well rehearsed, but other approaches may be needed. The UK's once-native turtle (*Emys orbicularis*) was lost several thousand years ago and is known only from one fossil site in East Anglia. But in Europe, these animals are still found, often in high densities. They can breed in rotting vegetation or sandy beaches. Most notably, they are air-breathing aquatic vertebrates that can thrive in warm and low-oxygen waters, feeding on carrion and rotting vegetation. The turtles may play a role in recycling such waste in rivers, lakes and ponds.

An exploration of the possible impact of this turtle on water quality is overdue. As with beavers, it may play an important role in supporting our rivers in times of stress and low flows. There is clearly a niche role for an air-breathing aquatic reptile!

Climate-trashing era began with white supremacists

9 September, p 21

From Adrin Neatrour, Newcastle upon Tyne, UK

Regarding the debate over the start of the Anthropocene Epoch, the era of human influence on planetary systems, perhaps it wasn't to do with geology at all. Before we created technologies that led to the Anthropocene, a change in attitude had to happen. I would pinpoint this as occurring in the 16th century, when white Europeans came to believe that they were superior, a conviction that underlaid the industrial-scale slave trade. They presumed they owned Earth. As its owners, they felt they had the right to treat the planet and its people in whatever way they wanted.

Aliens might advance without discovering fire

26 August, p 17

From Graham Brooker, Sydney, Australia

The article on how some alien worlds may lack the conditions for the discovery of fire suggests that smelting ores to extract metals is probably a prerequisite for the evolution of advanced societies. Yet it neglects the possibility of enzyme or catalyst-mediated manufacturing. For example, one of the hardest and longest-lasting materials in nature is dental enamel, and that only requires a temperature of 35°C (95°F) or less to produce. So, maybe there is hope for civilisations without fire.

From Martin Greenwood, Perth, Western Australia

Your story states: "Lab experiments have found that combustion can't fully occur in atmospheres with oxygen levels below about 18 per cent." Under what conditions of temperature and pressure does this hold? We can't assume alien atmospheres will always be at pressures and temperatures similar to Earth's.

Don't forget this twist to the standard model

9 September, p 36

From Nik Kelly, Liverpool, UK

Though I enjoyed your recent look at the standard model of particle physics, I was surprised the "How to break the standard model" section didn't mention teleparallel gravity, whose "twistors" may unify the electromagnetic force with that of gravity.

Fruit flies just wanna have fun? Maybe not

26 August, p 13

From Mark Wareing, Ashbourne, Derbyshire, UK

A study suggests fruit flies may prefer to sit on a rotating carousel for pure enjoyment. It could be argued that flying barrel rolls and loops would be more entertaining, if fruit flies like to have fun. Isn't it more likely that the flies choose the carousel for other reasons? For example, it might be easier to take off and avoid predators due to the airflow on a moving carousel.

The battle to get drugs for covid-19 in the US

2 September, p 22

From David Fremlin, Colchester, Essex, UK

Annalee Newitz, who has had covid-19, says that US doctors are "leery of prescribing [Paxlovid]. No one is quite sure why." Perhaps the doctors have prior experience of this antiviral? It seems that it is effective at relieving symptoms and possibly in controlling infectivity, but there have been some reports of the virus rebounding after a week or so.

For spear throwing, the Woomera was a winner

2 September, p 10

From Jane Lomax-Smith, Adelaide, South Australia

I had never heard of an atlatl, the ancient weapon in your recent story. But Australians may have heard of the rocket base developed at Woomera in South Australia, aptly named after an Aboriginal spear-launching device of the same name. This weapon is possibly of far greater antiquity than the one examined at Kent State University in Ohio.

High time to get used to using less energy

Letters, 26 August

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

As the years go by, it is increasingly apparent that nuclear fusion may, one distant day, become a reality, but that it is most unlikely to be a significant player in resolving our immediate climate woes. The root problem, I believe, is that everyone expects every joule of energy we currently consume from fossil fuels will be replaced by a joule from renewables. Quite simply, this isn't going to happen.

The only logical conclusion is that, as fossil fuel consumption must be ended soon, we shall need to face a future with less energy at our disposal. ▮

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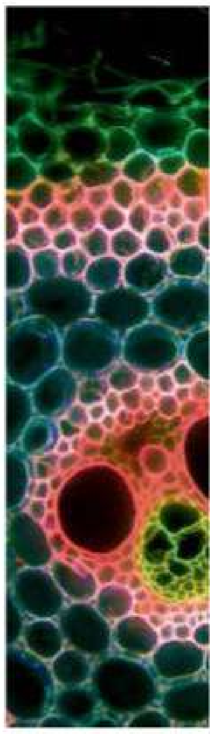

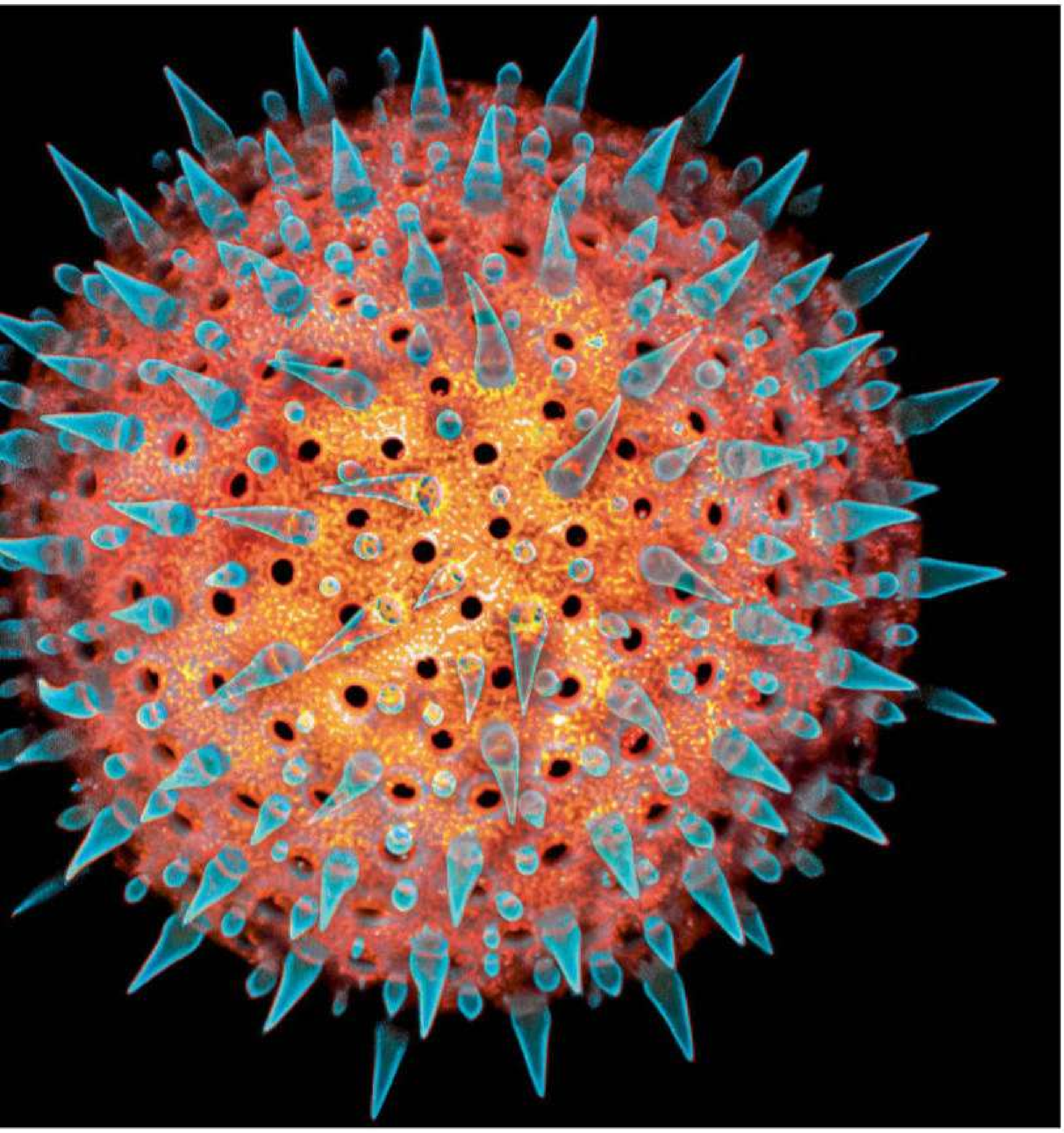

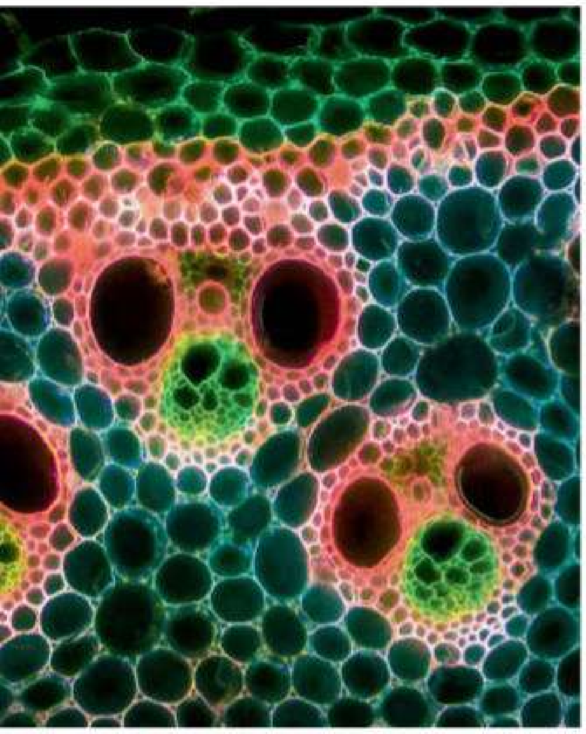

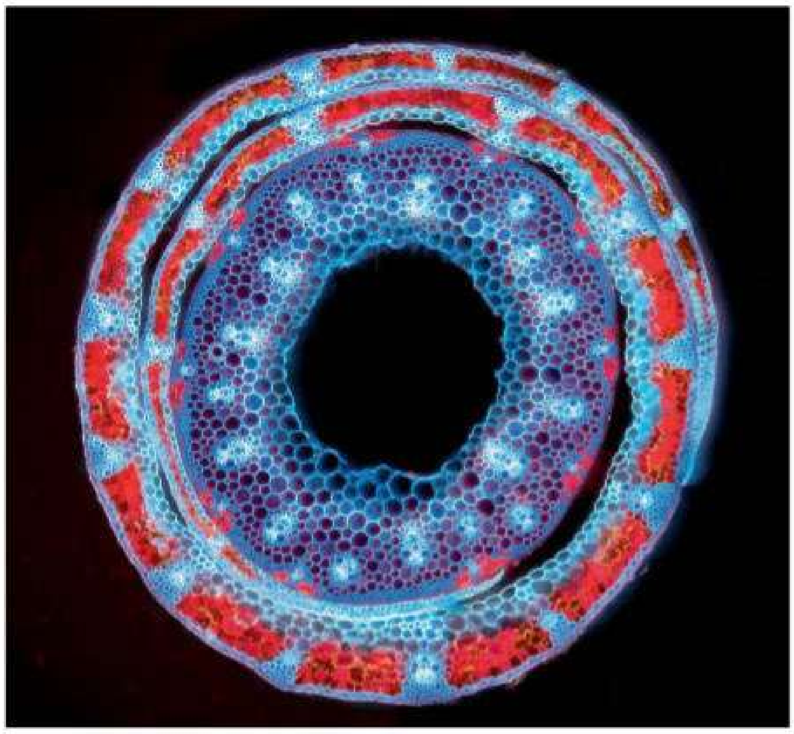

Lighting up

Photographer Jan Martinek

THESE are plants like you have never seen them before. Vibrant, diverse and possessing an almost microbe-like quality, these images of plant cells were taken by Jan Martinek at Charles University in Prague, Czech Republic.

As a plant cell biologist, Martinek is interested in the mechanisms that allow cells to shape themselves into the distinctive structures seen here. "Many of the images that I captured during my research also have some aesthetic qualities, so… I decided to share them on my Instagram account to promote science to the public," he says.

His account, @plant_microverse, showcases the intricacy and beauty of plant cells and molecules using mainly fluorescence microscopy. This employs fluorescent dyes and specific wavelengths of light to illuminate cells and molecules – making what is normally invisible suddenly visible, says Martinek.

The main image on the left shows the minute details of the roots of *Arabidopsis thaliana*, a small weed that is widely used as a model organism in research, for example in the study of genetics. At top right is a hollyhock pollen grain viewed using a confocal microscope, a kind of fluorescence microscopy that maximises optical resolution and contrast.

The smaller images show cross-sections that reveal the inner "plumbing" of two plants: the rhizome – an underground stem from which roots and shoots protrude – of a common reed (left), and the hollow stalk of a barley plant (right). The fluorescent blue indicates lignin, a polymer that provides the "backbone" for plant cell walls, and the red marks areas of active photosynthesis.

Gege Li

Taking it personally

Neuroscientist Camilla Nord tells **Liz Else** why mental health science is increasingly about what works for individuals – from psychedelic therapy to exercise regimes

CAMILLA NORD, who heads up the Mental Health Neuroscience Lab at the University of Cambridge, has just published her first book, *The Balanced Brain: The science of mental health* (Penguin). She explains how novel treatments, and a new emphasis on our sense of our body's internal states, could transform mental health.

Liz Else: You have packed in some surprises in your book. Let's start with what the title means.
Camilla Nord: I see mental health as a kind of homeostasis, as a balance, a very active state. It's a way of coping with the changes in our external environment and inside our bodies. In both cases, our mental health is constructing a view of the world that is an attempt at balance.

Is the body undervalued in mental health research?
One key message in the book is that bodily processes have a profound influence on our mental health, but they are often disregarded or oversimplified. Interoception, the sense of the internal state of our body, is so important because it provides a lens on those processes: it can give you specific information about the sense of your heart speeding, or general information like feeling nauseous. It's such a key filter through which we feel all our bodily processes. I think it is likely to play a role in mental health.

Many of the most influential experiments on interoception are about the heart because there are close ties between the beating of the heart and emotions. But the gut is another important source of interoceptive information, and some researchers think it may play a central role in mental health.

CLAUDIA GANNON

Mental health is about attempting balance, says Camilla Nord

Why?
Your stomach contracts at a very slow rhythm, but when you feel nauseous, it contracts at an irregular rhythm. My lab ran a study where we showed people disgusting images, which are very hard to look at. We gave some participants domperidone, an anti-nausea drug, which "normalises" the gut. Those who received the drug avoided the images less. What this means for mental health conditions is unexplored so far.

> "My lab ran a study where we showed people disgusting images, which are very hard to look at"

Are you planning to explore it?
I'm planning to research pathological disgust. Many people with post-traumatic stress disorder have fear-related PTSD, but some have disgust-related PTSD. This is very difficult to treat because exposure therapy (which is very effective for fear) doesn't work. I'd like to see if domperidone improves exposure therapy for people experiencing pathological disgust.

This is a very targeted way of tackling mental health. Are there other tools you value?
Computational psychiatry, the application of mathematics to mental health, is exciting because it helps us define precisely the differences in the behaviours and thoughts of people with different mental health conditions, and how treatments affect those conditions.

Is this part of a shift towards an evidence-based approach?
One of the ultimate goals is to move away from a diagnostic framework based on people in a room voting on what makes a psychiatric condition. There needs to be empirical evidence about where we draw the lines between conditions – something that has held us back from new treatments. How can we expect the same treatment to reduce depression in two people with totally different symptoms? This is a very difficult prospect, but we need to be looking for common mechanisms that cut across what we now think of as diagnoses, and tailoring treatments.

What if the therapies don't work?
Even very effective psychological therapies may work in 50 or 60 per cent of people, but there are variations in how well. And if we can better understand techniques like, say, cognitive distancing, we can ask what can we add to help it along. Suppose before a cognitive behavioural therapy session, someone could take a particular drug that let them engage better with that session.

That sounds radical.
Right now, someone might be on long-term medication and receive therapy. In my lab, we're interested in flipping that and asking, what if someone doesn't need to take a drug every day, but a drug would help them with a particular therapy session or a particular therapy? Or maybe people could get "homework", doing something that's difficult for you and then reporting back to your therapist.

Maybe that experience could be made more powerful if it was combined with a biological augmentation. One of the most effective is psychedelic therapy, including MDMA and psilocybin.

Will this personalised approach be expensive?
Think about an MRI scan. A good one costs £500. But what if you could use it to predict if someone is better taking antidepressants or receiving CBT? A personalised framework,

maybe involving more investment at the start, would save money in the long run.

Is there is a "mentally healthy" lifestyle?
When people think about the science, they think about a particular brain chemical they've heard is different in mental health [conditions]. But they don't think their own lifestyle might have biological effects on their mental health: obvious things like exercise, sleep and diet have effects on your biology and thus mental health.

> "One study I like shows that exercising for more than a couple of days a week could make you less happy"

What about exercise?
One study I like shows exercising for a couple of days a week is associated with better well-being, but beyond that it could make you less happy. That tells us even something that seems beneficial has individual components. One friend said, isn't it unusual that even though I really like exercise, I don't think it's for everyone? I thought, no, that's the point: you shouldn't extrapolate from your own or someone else's experience.

The ancients' prescription was "everything in moderation". Are you looking back at that?
I probably am. One thing that inspired me when I wrote the book was a contrariness against the idea that everything fun is bad for you. I thought, that's so wrong. I even write about the positive mental health effects of alcohol, some recreational drugs, aspects of diet like sugar – and a late night out. ▮

Talking to aliens

A fascinating book asks if we could ever commune with other life forms, says **Pat Kane**

Book
Life and Language Beyond Earth
Raymond Hickey
Cambridge University Press

WHAT language might an alien use? As a speculative answer, Denis Villeneuve's epic sci-fi movie *Arrival* couldn't be more intriguing. Louise the linguist is asked to board a spaceship to interpret circles of ink spattered onto glass by ghostly, seven-limbed heptapods. Their circularity expresses the aliens' non-sequential view of time.

One of the many robust joys of Raymond Hickey's magisterial *Life and Language Beyond Earth* is the blunt confidence with which he dismisses *Arrival*'s circle-language. "No animal would use such a short-supply resource as their ink for primary communication," he writes.

Hickey doesn't have much time for genuinely "weird life", as he calls it. His mission is to hypothesise about how "exobeings", as he calls them, might acquire languages, and he starts from the one test case he is sure about – us.

Amy Adams tries to communicate with heptapods in *Arrival*

PHOTO 12/ALAMY

Just like humans, says Hickey, in order to be sentient and purposeful, an alien would have to develop a "runaway brain", one with capacities beyond those needed to survive. To construct machinery such as communication devices, they would need dexterous limbs and digits – and "a language-like communication system" to coordinate their activities, he says.

As he considers the ways aliens might hear or produce noises, or how their ability to move their bodies in space might shape the metaphors in their discourse, Hickey's exobeings form in your mind. But they are more like the bridge crew of the starship Enterprise than *Arrival*'s heptapods. That is, Hickey imagines language-using aliens will be essentially humanoid entities, with some minor evolutionary divergences.

He makes clear that, out of all possible "contact" events, only receiving a signal from beyond our solar system is remotely likely. The next most probable is discovering exoplanets that don't just emit "biosignatures" of life, but "technosignatures" too.

So, no encounters with time-bending heptapods, writes Hickey. But maybe meaningful blocks of patterned, language-like information will reach us – if exo-civilisations are, or have been, beaming them out.

Hickey's teeming yet coherent study makes the claim that, if we assume they are language-users like us, we will be better able to pick the alien needle out of all those intergalactic haystacks. ▮

Pat Kane is a writer based in Glasgow and London

New Scientist *recommends*

Timothy Revell
Deputy US editor
New York

I've recently been captivated by **The Retrievals**, a podcast from *The New York Times* and the makers of *Serial*. It follows the wild case of a nurse who repeatedly stole fentanyl from a fertility clinic and replaced it with saline. It took a long time to uncover what was happening; meanwhile, dozens of women had to undergo in vitro fertilisation (IVF) without receiving any pain-relief medication – though their doctors didn't know that at the time.

NYT/SERIAL

I've also read a couple of great books. The first was **Traffic** by Ben Smith, following the rise (and fall, for many) of the first internet media companies. It's an insider look at what the early days of *BuzzFeed*, *Gawker*, *The Huffington Post*, the *Drudge Report* and more were like.

The second is **Determined** by Robert Sapolsky, in which the famed neuroscientist builds his case that free will doesn't exist. I found it both fascinating and challenging – though I'm not sure if I really had a say in the matter.

The TV column

Worth staying up for Two friends with insomnia spend their nights chatting about possible treatments in *Still Up*, a rare look at how the condition can affect relationships – and a charming romantic comedy, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley

APPLE TV

Antonia Thomas as Lisa, who falls for her friend and fellow insomniac

TO GET the most out of *Still Up*, a new romantic comedy airing on Apple TV+, I watched it in the dead of night. It felt wrong to do otherwise, given its subject matter: Danny (Craig Roberts) and Lisa (Antonia Thomas) are best friends bonded by insomnia who stay up late together, chatting over FaceTime and discussing possible treatments for their condition. Slowly, their friendship becomes charged with romantic tension, despite Lisa's relationship with her boyfriend Veggie (Blake Harrison).

I count myself lucky to have never had severe insomnia, though the bouts of sleeplessness I have experienced were no joke. Yet *Still Up* finds plenty to joke about: rather than a deep dive into the difficulties of life with insomnia, it pokes fun at the litany of remedies often suggested to those who struggle with sleep. Lisa considers taking "Snoozers", for instance, a new sleeping pill that makes everything taste like cabbage, and Danny recalls one book's advice that he should find relief by praying to a Norse god.

The world of *Still Up* hinges on a simple observation: that cities can, at night, be very strange places indeed. The London that Danny and Lisa inhabit is purposefully weird, full of odd encounters and unexpected capers. All this idiosyncrasy can be pretty hit-and-miss: Lisa's run-in with light-fingered teenagers on the night bus is amusing; Danny's attempts to avoid a birthday party for his neighbour's cat are much less so.

> **"The world of *Still Up* hinges on a simple observation: that cities can, at night, be very strange places indeed"**

The series is better when it stays away from groan-inducing quirkiness. Thomas and Roberts are two formidable comic actors when given the right material – thankfully, as *Still Up* progresses, the writing relaxes and the leads are allowed to shine with simpler, funnier dialogue mined from their shared situation.

As well as his insomnia, Danny is coping with agoraphobia, and has been unable to leave his flat for a number of years. His agoraphobia gives the show more emotional weight, and I hope it will be explored further, rather than conveniently conquered, if a second season is commissioned.

Because of Danny's situation, his relationship with Lisa is conducted via nightly video calls and voice notes, a rare positive take on technology's impact on modern love. (Those of a more cynical mindset should try to ignore the Apple product placement.) The series is also a surprisingly good satire of digital culture, from the distractingly sexy narrator of Lisa's sleep app to Veggie's side hustle making unboxing videos of tools for unboxing videos for YouTube.

Still Up has all the trappings of a classic rom com, right down to the implausibly spacious flat that Danny can somehow afford while working as a culture journalist (which hit a little close to home for this reviewer). Happily, though, it has followed the modern trend of embracing a genuine love triangle, where Danny and Lisa's alternative partners are actually appealing, at least to some degree.

It is also refreshing that Lisa, rather than Danny, is allowed to be less than saintly – she sends her daughter to school despite knowing she has chickenpox and undermines Danny's love life with repeated invasions of his privacy – but she is no less compelling for it. What's more, the strain her insomnia places on her relationship with Veggie is something real – and experienced by many – that grounds the series in later episodes. It is here that the show finds its potential. ▮

TV
Still Up
Steve Burge and Natalie Walter
Apple TV+

Bethan also recommends...

TV
Starstruck
BBC iPlayer (UK) or Max (US)

Jessie (Rose Matafeo) is an underemployed millennial who ends up sleeping with A-list actor Tom (Nikesh Patel), in this delightful screwball comedy.

Catastrophe
Amazon Prime Video (US)

American ad exec Rob (Rob Delaney) has a six-night stand with Sharon (Sharon Horgan) while on a business trip to the UK. When Sharon learns she is pregnant, Rob decides to stay in London to see if they can make things work.

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JON KRAUSE

Is free will an illusion?

Physicists and philosophers have long argued over whether we truly make our own decisions. Can neuroscientists finally settle the issue, asks **Clare Wilson**

SUPPOSE you approach a fruit bowl overflowing with apples, oranges and bananas, all perfectly ripe. On this occasion, you choose an orange. Or do you? Because although it may feel like you were free to pick an apple or a banana instead, many of those who contemplate such things insist that you aren't at liberty to choose at all.

The same goes for all sorts of decisions we fret over, from the trivial to the consequential. If we could somehow rewind the universe, they say, you would behave in exactly the same way – because that is how your brain is made. Your sense of having free will is just an illusion.

The implications of such a claim are alarming because they force us to rethink many cherished assumptions. If our choices are somehow predetermined, there is no point agonising over moral dilemmas and less justification for punishing people for their crimes. This stuff matters. But can it really be true that none of us, as the poet William Ernest Henley put it in his stirring poem *Invictus*, is the captain of our soul?

While that question has long been the preserve of the physicists, philosophers and religious scholars, a growing number of biologists are now weighing in. Only this month, two leading neuroscientists have published books on the subject, both of which claim that a new understanding of the brain supports their case. So, with the debate having moved into new territory, can we finally figure out, once and for all, whether we have free will?

The question has fascinated people since the time of the ancient Greeks, who debated how free will could be reconciled with what they saw as a "deterministic" universe, where everything that happens is governed by prior causes. The subsequent march of science seemed to support this deterministic world view, from Isaac Newton's discovery of the laws of motion in the 17th century to the orderly arrangement of elements in the periodic table.

For many, free will is ruled out by classical physics, which tells us that everything that happens in the physical world has a cause, whether we are talking about snooker balls careening around a table or planets whirling around the sun, and is therefore predictable according to physical laws. Our decisions must surely be outputs of our brains, which are ultimately made of physical matter, regardless of how complex they are. And their inner workings must be subject to those same laws of classical physics as planets and snooker balls. If only we had a sufficiently powerful brain scanner – one that could read out the position of every neuron, every synapse, every molecule – our decisions could be predicted before we made them.

A possible lifeline for believers in free will came with the arrival of quantum physics in the early 20th century. This says that subatomic particles can occupy multiple different states at once, existing as a spread of probabilities that only "collapses" into something definite when measured, or observed. While the particles behave classically en masse, when single particles can be observed, they can take a spread of values within a certain range and these seem, as far as we can tell, to be quite random. In other words, the universe, at its most fundamental, is non-deterministic.

A second get-out clause comes from a branch of physics called chaos theory, which describes how complex systems that are highly sensitive to small changes end up behaving in unpredictable ways. This shows that, even with all the information to hand, we couldn't, in fact, predict everything that happens in the universe.

Yet neither of these two lifelines seems very secure. Maybe our brains do have

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The experience machine
Join philosopher Andy Clark as he explores how our brains construct reality via predictions newscientist.com/nslmag

elements of randomness or unpredictable processes, but that doesn't sound much like being the captain of your soul.

Which raises the question: should we really be thinking about free will at the level of fundamental physics? Some argue that our capacity for free will, should it exist, would operate not at the level of particles and atoms at all, but in complex networks of brain cells. Decision-making, in other words, is a biological phenomenon, which is where neuroscience enters the fray.

It began in the early 1980s with a simple experiment carried out by Benjamin Libet, a neurophysiologist at the University of California, San Francisco, that has been endlessly repeated, elaborated on and argued about ever since. The set-up was to ask a volunteer to sit with their hand on a button and to press it after a random interval of their choosing. They were asked to note, by means of watching a timer, the instant they chose to move. They also had an electroencephalogram, or EEG, with electrodes placed on their scalp to monitor changes in brain activity.

Unsurprisingly, Libet's experiment found that people became aware of their decision to hit the button a fraction of a second before they actually pressed it. What was startling was that activity in the part of the brain that controls hand movements, started to rise before the person believed they had taken the decision – on average, about a third of a second before. The result shifted the free will debate on its axis because it suggests that whatever is making the decision isn't our conscious experience – the thing that feels like the "captain" inside our heads.

That seems to tally with psychological research demonstrating that we can easily be mistaken about our decision-making processes. When people are tricked into thinking they made a certain choice that they didn't, they are surprisingly willing to make up plausible "explanations" for their decision. When asked to choose the most attractive person from two pictures, for example, they are later able to justify their choice despite the fact that the experimenter has secretly switched the photos. This phenomenon, sometimes called confabulation, is often interpreted as evidence that just because we feel like we have freely made a decision, that isn't necessarily the case.

On the other hand, these are contrived circumstances, says Adina Roskies, a philosopher at Dartmouth College in New Hampshire. "There are certainly cases in which you can fool people into thinking they've done something when they haven't. But that does not suggest that all the time, when we think we've done something, we haven't done it," she says. After all, we don't take the success of visual illusions as a sign that no one can really see.

ROSIE BARNES/MILLENNIUM IMAGES, UK

"SHOULD WE REALLY BE THINKING ABOUT FREE WILL IN TERMS OF FUNDAMENTAL PHYSICS?"

JUSTIN LAMBERT/GETTY IMAGES

Conscious choices

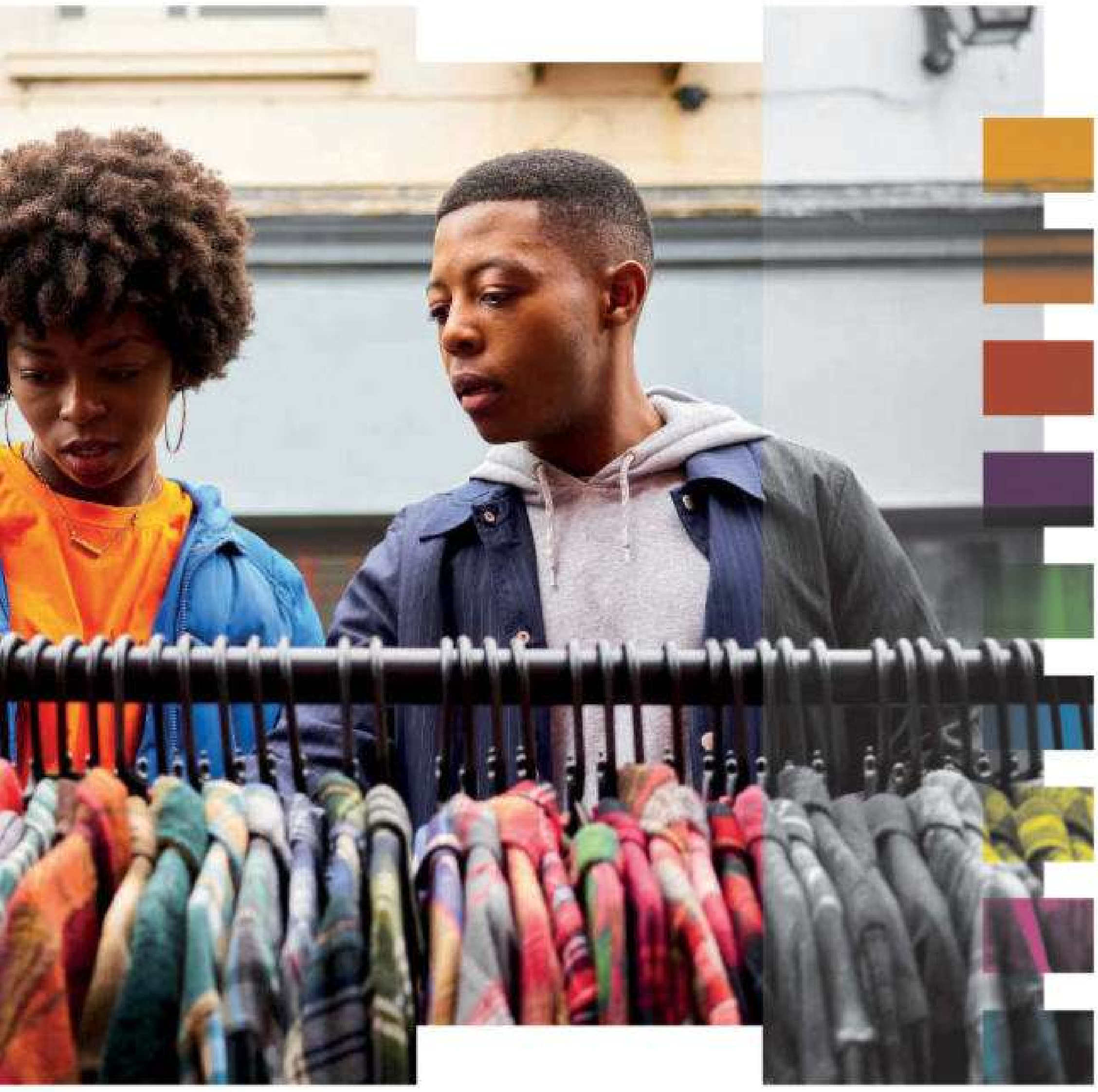
The Libet result has been challenged in other ways, too. Some critics argue that it is an artefact of the instructions given in the experiment. Subjects are told to "let the urge to act appear at any time without any pre-planning or concentration on when to act". In fact, activity in the relevant part of the brain tends to randomly fluctuate up and down. On being effectively told to act on a whim, people might be interpreting a higher level of unconscious brain activity as their cue to press the button, says Kevin Mitchell, a geneticist and neuroscientist at Trinity College Dublin, Ireland. "The set-up is designed to take any deliberation out of it."

Perhaps the most compelling criticism, however, comes from a 2019 study that tweaked the Libet experiment, asking subjects to make a more meaningful decision: to press a button to decide which of two charities would receive $1000. This found no rise in unconscious brain activity before people felt they had made the decision.

That suggests the Libet finding applies only to arbitrary decisions, which could be driven by random fluctuations in brain activity, but is irrelevant for deliberative decisions, says Uri Maoz at Chapman University in California, who was involved in the study. "Let's say I can predict when you [press a button] – who cares? But if there's a burning car with a baby inside, are you going to save the baby? Those are the kinds of decisions we care about."

While Maoz's team saw no evidence of the Libet-style brain activity in the movement part of the brain, it is possible that a similar pattern of activity could be happening elsewhere. His team is continuing to look for such a signature using functional MRI scanning, which should be more able to detect activity in deeper regions of the brain, he says.

But Maoz believes that more light will be shed by investigating this question as it relates to animals, even very simple ones. "Free will has really been studied in humans, but there are now a lot of things we can study



in animals because we have technology for recording and stimulating [brain] activity in animals," he says.

The behaviour of simple animals like fruit flies is usually assumed to be highly deterministic, involving reflexive responses to external stimuli. In fact, it is anything but, says Björn Brembs at the University of Regensburg in Germany. Brembs and his team have studied the flight patterns of fruit flies placed in a white drum with no visual cues – effectively a sensory deprivation chamber – to remove all possible stimuli. They found that the flies' zigging and zagging inside the drum was neither deterministic nor random, but bore mathematical hallmarks of chaotic systems and was impossible to predict. More recently, in 2021, another team found similar signatures of chaos in the outputs of neurons that govern when *Aplysia* sea slugs start feeding on algae.

Brembs says similar systems could be at work in human brains when we make decisions. If so, it wouldn't prove we have free will, but it would at least scupper the argument that, given enough information, it would be possible to predict all our decisions – we couldn't even predict the twists and turns of a fruit fly. "It could provide some component of choice," he says.

It feels like we make numerous decisions every day

"THE MORE WE DISCOVER ABOUT THE BRAIN, THE LESS ROOM THERE IS FOR FREE WILL"

Yet not all those who study animal brains are so confident that it will release us from the shackles of determinism. In fact, the latest argument against free will comes from Robert Sapolsky, a neuroscientist at Stanford University in California. In his new book, *Determined: Life without free will*, Sapolsky argues that the more we discover about how the brain works, and the many different influences on human behaviour, the less room there is to squeeze in the capacity for independent decision-making.

Inescapable influences

To take just a handful of examples: geneticists have found hundreds of DNA variants that influence our tendency to be depressed or impulsive; epidemiologists have shown that how well a fetus is nourished during pregnancy can cause enduring "epigenetic" changes to DNA with lifelong consequences for mental health; and social scientists have demonstrated how experiences in our early life may mould our tendencies to be anxious or to commit crimes. "It's one big seamless arc," says Sapolsky. "There's no aspect of behaviour that's not being influenced by a zillion of these factors."

We may not yet know everything about how the brain makes decisions, says Sapolsky, but one day we might understand near-enough everything. And even now, he adds, we know enough to suggest we won't make any startling new discoveries to indicate that the brain can avoid being influenced by such factors. "It would require some findings that defy most of biology to find a place to shoehorn [free will] in. There's no crack where you could discover that here's where our neurons, instead of communicating with neurotransmitters, start whispering to each other – and that's why someone decided to rob the liquor store."

Sapolsky's argument goes to the crux of his interest in how we think about morality and criminal justice. As someone who, earlier in his research career, helped to uncover the way that stress hormones can change the brain, Sapolsky has previously acted as an expert witness in court cases, arguing that defendants should get shorter prison sentences because they were abused as children. "I say to the jurors: 'If you had the exact same upbringing, with the exact same biology, you'd be sitting at the table as the defendant'," he says.

Such ideas have been challenged, however. As Roskies points out, a decision can be influenced by something without being

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We may not have as much freedom to choose as we like to think

"AGENCY IS A CORE PROPERTY OF LIVING THINGS. IT IS HERE THAT WE CAN FIND THE SOURCE OF FREE WILL"

determined by it. A gene variant or stress hormone could make a choice more likely without making it 100 per cent certain, for example. "If you think free will exists, that's not to say that there aren't influences and constraints on our behaviour," she says.

And neuroscience isn't the only branch of biology that has something to say about free will, says Mitchell. "If we want to understand how human beings do things – that is, where causal power [for our actions] comes from – then that question extends back to say: 'Well, how does any organism do something?'" The answer, says Mitchell, lies in the evolution of biological agency, or the ability to act with intention or purpose, an argument he makes in his new book *Free Agents: How evolution gave us free will*.

As Mitchell sees it, when the first simple life forms appeared on Earth about 3.7 billion years ago, one of their most interesting essential qualities was that they did stuff. Before that, things happened: grains of sand tumbled around, chemicals reacted and volcanoes spewed out lava. But those were inert physical processes. The first life forms, however, used energy to work against the second law of thermodynamics – the principle that everything tends to become more disorganised over time – and hence stay alive. "Agency is a really core property of living things that we almost take for granted, it's so basic," says Mitchell.

It is here that we can find the source of our free will, he says. In fact, this is what the nervous system evolved for. "It is primarily a control system, the job of which is to define a repertoire of actions and choose between them. This control system has been elaborated over evolution to give greater and greater autonomy."

Rethinking reductionism

For Mitchell, it is a mistake to think we can always reduce complex systems to their component parts and consider causation in nervous systems, say, at the level of their atoms. Contrary to this "reductionist" approach, complex systems like brains can only be understood by considering their interactions at higher levels of organisation.

This view has recently been put on a firmer footing by research that reconsiders the reductionist approach of seeking "microscale" causes. In 2022, Erik Hoel, then a neuroscientist at Tufts University in Massachusetts, analysed more than a dozen different kinds of causation in complex systems, proposed by researchers in fields from statistics to genetics and psychology. In every case, he found some form of "causal emergence" – where the causes of some phenomenon or behaviour emerge not at the microscale but a higher or more coarse-grained level of the system.

In the case of decision-making, then, a person's thoughts and feelings and memories are as much genuine causal forces as what happens at the level of atoms and neurons. "The idea that every event has a cause is only a problem for free will if it's taken to mean that every cause is at this lowest level, it's all physics," says Mitchell. "But the entire structure of a nervous system can be a cause of things – you can be a cause." Which suggests we might just be the captains of our souls, after all.

Whether any of this will allow free will sceptics and believers to reach an accord is far from clear. The opposing sides can't even agree on what it would take to provide clinching evidence either way. Sapolsky will believe in free will only if some aspect of human behaviour can be shown to be completely devoid of prior influences. "Here are the neurons that caused it to happen – show me that they would have done the exact same thing if all the surrounding neurons sculpted by the previous history of your life had been different," he says.

Mitchell says that is setting the bar impossibly high. "What kind of a being would be behaving free from any prior causes? They wouldn't have a reason for doing anything, because reasons are past causes – it would just be a random behaviour generator." But he adds that it is difficult to conceive of anything that would convince him that his argument is wrong, because it isn't a simple, testable hypothesis. "It's hard to say there's some particular experiment that could show we do or don't have free will," he says.

Roskies, for one, isn't holding her breath. "There have been thousands of years of discussion about this issue," she says. "If there were a simple answer, we would have figured it out by now." ▮

Clare Wilson is a health reporter at *New Scientist*

How to avert a climate emergency

Decades of negotiations have so far failed to put the brakes on carbon emissions. Former climate adviser to the British government **Simon Sharpe** tells Michael Marshall how we can decarbonise the world five times faster

IT IS easy to feel anxious about the state of the climate. July was the hottest month on record and hurricanes, floods and wildfires have recently ravaged many countries. Despite this, last week, the UK government delayed its plans for net zero. Rising carbon emissions put the world on course to increase its average temperature by about 2.7°C above preindustrial temperatures by the end of this century – almost double the Paris Agreement's target of 1.5°C. But we can decarbonise the global economy far quicker, says Simon Sharpe, who has spent a decade working at the forefront of climate change diplomacy.

Sharpe joined the UK Foreign Office in 2005, where he worked on everything from human rights policy to counterterrorism. In 2012, he stumbled on a climate science lecture that made him realise catastrophic climate change wasn't a negligible risk, but a likely scenario, and needed to be communicated to governments as such. He soon took on a series of climate-related government jobs, culminating in a high-profile role at the COP26 climate summit in Glasgow, UK, in 2021.

Today, Sharpe is a senior fellow at the non-profit World Resources Institute and director of economics at the philanthropically funded organisation Climate Champions.

In his recent book *Five Times Faster*, Sharpe argues that it is time to see the economy as dynamic and invest in new technologies, rather than protecting the status quo. The institutions that are supposed to be helping us tackle climate change, he ›

NABIL NEZZAR

says, are inadvertently slowing us down. He tells *New Scientist* what has gone wrong with our approach to climate science, economics and diplomacy – and how we can still keep the rise in global temperatures below 1.5°C.

Michael Marshall: If I were to sum up your book *Five Times Faster* in five words, it would be "you're all doing it wrong".
Simon Sharpe: That is certainly the message. But, of course, I'm also trying to say: "This is what it would look like if you did it right."

In the book, you write that "science is pulling its punches". What do you mean by that?
A lot of the information generated by climate change scientists and presented to governments is done in the form of prediction, rather than risk assessment. Prediction focuses first on what's most likely to happen, and second on if it has an impact on anything we care about. Risk assessment asks more or less the same questions, but the other way around. First, what's the worst that could happen in relation to something we care about, and second how likely is it to happen.

We don't know as much as we should about worst-case scenarios for climate change, and what we do know isn't put at the forefront of the information that's communicated to governments. If you want your political leaders to act strongly, then a minimum requirement is that they know there's a bloody enormous problem.

Scientific culture can be a barrier to this because scientists prefer to communicate the findings in which they have the most confidence. Sometimes, these are less relevant to society than the possibilities that are highly uncertain but potentially catastrophic. Scientists need to be bolder in talking about worst-case scenarios. Governments can help by asking the right kinds of questions.

You draw an analogy with counterterrorism: policy-makers don't worry about the most likely thing to happen tomorrow, because that is nothing. Instead, they focus on the worst possible attacks. What is an example of a worst-case scenario for climate change?
London obviously has a risk of flooding. Engineers built the Thames Barrier half a century ago to prevent that. There's one study – which isn't widely recognised – that makes an estimate of London's limit to adapt and protect itself against global sea level rise. The limit is about 5 metres.

"Don't worry so much about your carbon footprint. Think more about your point of leverage"

Emission mandates have driven the boom in electric vehicles

CFOTO/FUTURE PUBLISHING VIA GETTY IMAGES

There's a lot you can do before that: extend the barrier, build it taller, build a new barrier further out to sea. But the estimate is that, once you get to around 5 metres of global sea level rise, the only way you could protect London is to build a wall around the city centre and pump the river Thames over the top. The difficulty, the expense and the residual risk that entails would all be so bad that you probably wouldn't bother.

Having established there's a threshold, you then have to ask: how likely is that to be crossed? If you look at the Intergovernmental Panel on Climate Change (IPCC) projections, a sustained warming of 2°C is estimated to commit the world to sea level rise of more than 10 metres over the long term. This is double London's limit of adaptation. The IPCC's most recent Assessment Report included a plausible worst-case scenario for global sea level rise for the first time. In that scenario, we cross the 5-metre mark around the year 2150.

That's quite shocking if you're a British politician working on the banks of the Thames, as they all are. Politicians should know that. But whenever I mention it to a UK civil servant or government minister, they are stunned. Why on Earth did they not hear that before?

In *Five Times Faster*, you argue that the global economy, like the climate, is less stable than we expect – and that this is a source of opportunity.
Part of the problem is that we've thought about policy on climate change using old economic ideas, such as equilibrium. This means that the economy is balanced because supply and demand in the market are equal to each other. The idea of equilibrium was brought into economics in the 1870s for a strange reason. It wasn't because anybody looked at the economy and said: "That looks like a system in equilibrium." It was because some economists wanted economics to look like a science. They thought that meant it should be described with maths equations, but to make any of the equations solvable, the system had to be in equilibrium.

In economics, equilibrium is defined as a situation where nobody has any reason to change their actions, so that the status quo can continue. If you think about the economy, it's pretty hard to think of a situation where that is the case. When we make this false assumption, it creates a massive bias against doing anything to change the economy. By definition, anything you do to it makes it worse.

The Thames Barrier can't protect London from flooding forever

PETER DAZELEY/GETTY IMAGES

How does this affect how we go about finding solutions to climate change?
Governments are still getting advice from many quarters telling them the most efficient thing they can do is put a price on carbon. In this picture, the risk of climate change is understood to arise because of a deviation from the economy's normal equilibrium state. There is a "market failure" because the interests of the private sector aren't aligned with society. Putting a price on carbon fixes this failure and returns the economy to equilibrium.

What is the alternative to carbon pricing?
If the economy is a thing that changes, and if your goal is structural change, then it makes sense to invest in new technologies and new systems. This activates reinforcing feedback loops in the growth of those new solutions, such as economies of scale and learning by doing. Those are really powerful dynamics. That's what drives Moore's law, which doubles the processing power of computers every couple of years. That's what has driven solar power to fall in cost by a factor of 10,000 over the past half-century.

People have got this idea of carbon pricing stuck in their heads, but as soon as you point to past technology transitions, it's obvious. Nobody thinks we made the transition from horses to cars by taxing horseshit. Nobody thinks that we created the internet by taxing letter writing. Why would it be any different for the transition to the clean economy?

So we need a new kind of economics?
Yes. There's a new approach called complexity economics or evolutionary economics. It models the economy as an evolutionary system which is dynamic and constantly changing. Economic behaviour is determined by both individuals and society as a whole. That gives you whole new ways you can simulate change and understand how to make interventions that will be successful.

What does this mean in practice for governments struggling with the net-zero transition?
Early in the transition, in any sector, the most important thing governments can do is invest in creating new solutions. That means investment in research, development and technology demonstration. It also means investment in targeted subsidies so that these solutions can take root while they are still more expensive than the fossil fuel alternatives.

Once those solutions become competitive, regulation can force industry to invest in them. You see that now in road transport. The leading countries have zero-emission vehicle mandates where they tell the car manufacturers: "If you want to sell cars, then this year 20 per cent of the cars have to be zero-emission, and next year it'll be 25 per cent, and so on up to 100 per cent." You don't have to spend public money on those policies, as you're just reallocating private investment. Those kinds of policies are incredibly effective.

On the international level, a lot of effort has gone into trying to create an agreement where every country signs up to binding carbon emissions targets. Has that effort been wasted?
That has been a great mistake of climate change diplomacy for the past 30 years. We have a negative-sum game where we're all trying to agree how to divide up the global carbon pie. There is, I argue, a positive-sum game, which is saying: "Hang on a minute, in all of these sectors, the zero-carbon solution could eventually be better than the fossil fuel solution. Why don't we work together to get there quickly?"

That's not in everybody's interests. Saudi Arabia isn't going to be the biggest supporter of the transition to electric vehicles. But we don't need to work with Saudi Arabia on that one. The US, European Union and China together are about 60 per cent of the global car market. Working with those three actors is just fine. They set the pace. They'll bring the entire global automobile industry with them. The crucial thing is that, in each sector, you need to work with a critical mass of countries that are capable of shifting the global market in that sector.

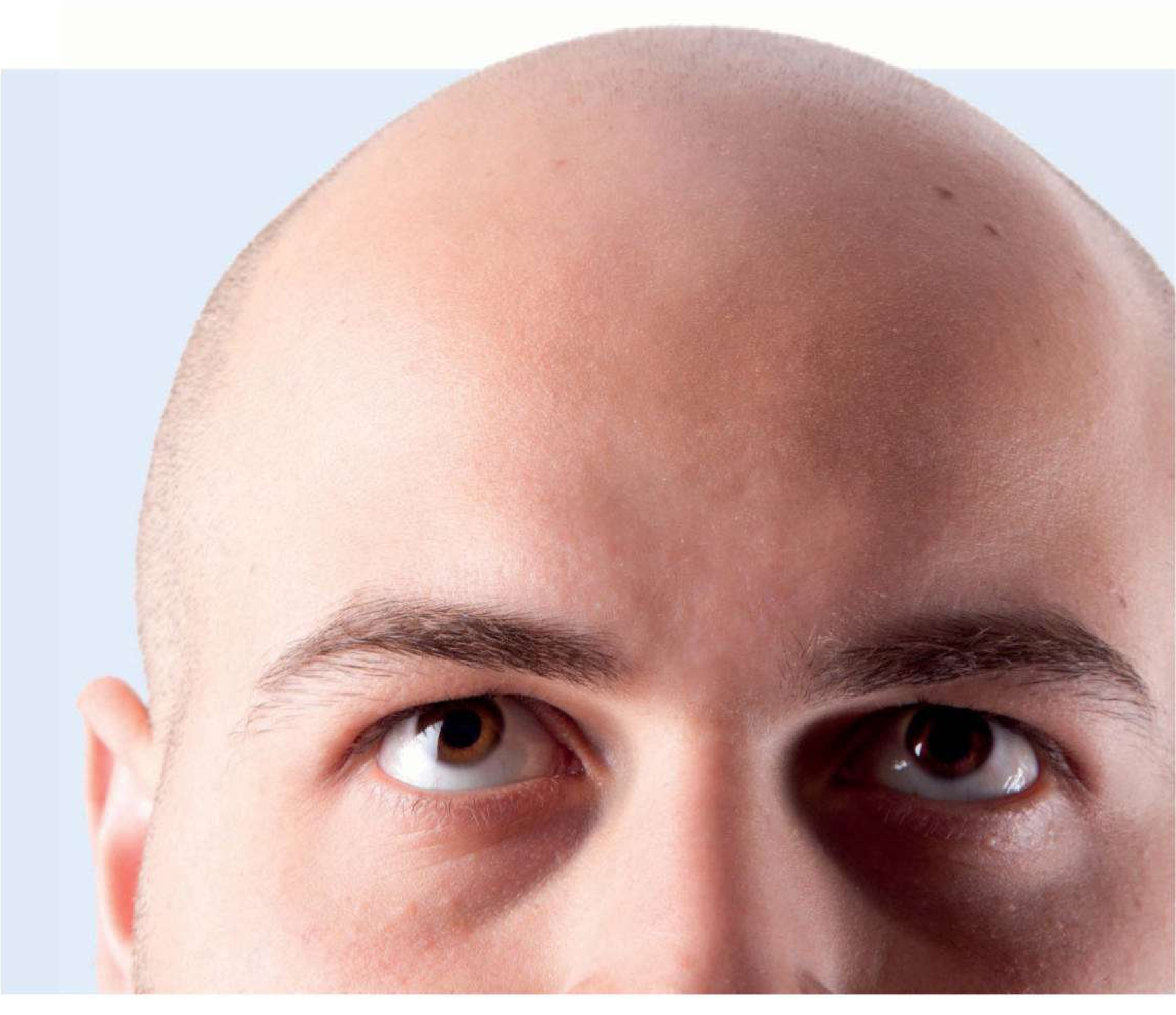
We have spoken a lot about what people in governments can do. What about the rest of us?
Don't worry so much about your carbon footprint. Think more about your point of leverage. What is the thing that you can do better than most people to, in some way, bring about system change? It may simply be voting for the right party. That's something all of us can do: exercise our democratic rights, carry on voting, campaign.

For many people, it's likely to be related to their profession. What kind of organisation do you work for? What can it most usefully do? The point of leverage is always to do with the core capabilities of an organisation. For example, if you're a university, what you research and teach is more important than whether you've insulated your buildings. If you're an advertising company, withholding your business from media that publish climate misinformation is more important than choosing the vegan option when you take your clients out for lunch. This is more powerful than just thinking about your footprint. ∎

Michael Marshall is a freelance writer based in Devon, UK

A hair-raising pursuit

Male pattern baldness may soon become a thing of the past, as our understanding of how hair grows reaches new heights, finds **Joshua Howgego**



BAYTUNC/GETTY IMAGES

I'LL level with you: a part of me didn't want to write this story. When I first realised that I was losing my hair, I found it important to mention it often in conversation. I was so embarrassed about it that I was trying some sort of reverse psychology. But I soon realised that if there was one thing less attractive than my balding head, it was how much I was talking about it. I am joking, of course: there is nothing wrong with being bald. Still, for me, the prospect is terrifying. My hair is a big part of my identity, so to lose it is crushing.

I'm not alone. By the age of 50, between 30 and 50 per cent of men have begun to experience male pattern baldness. Despite there being plenty of handsome hairless men out there – I'm looking at you, Thierry Henry – studies suggest that people tend to perceive bald men as less attractive and less friendly. And we don't need science to tell us that this can be deeply upsetting.

So although I have dialled down the discussion of my growing bald patch, I have been quietly digging into the science of hair loss – and what I found is worth shouting about. It is common knowledge that some treatments can slow hair loss. What is less known is that as we are coming to understand the reasons why male pattern baldness causes people to lose their hair, we are finding new strategies to restore it. There may soon be a way to not just slow balding, but reverse it.

In a field where tales of miracle cures are ten a penny, it is important not to overpromise. Still, there is a sense that the science of hair is advancing at breakneck speed. "People are now starting to get excited that we're reaching a tipping point," says biologist Maksim Plikus at the University of California, Irvine.

There are many reasons why people lose hair from their heads. It can happen suddenly after an infection or chemotherapy. Sometimes, people can lose patches of hair through an autoimmune condition called alopecia areata. But the most common type is androgenetic alopecia, or male/female pattern baldness. In men, we know that the condition, in which hair loss begins around the crown and forehead, is related to male sex hormones, but we don't understand the exact trigger.

The female version tends to cause an overall thinning that rarely progresses to total baldness. It is also thought to be caused by sex hormones, but again the mechanics elude us.

Through the ages, people have looked to a variety of unlikely remedies for baldness, from donkey hooves in ancient Egypt to fresh air and exercise in Victorian England. A quick look online and the modern-day choices are just as bamboozling: scalp rollers, caffeine shampoo, laser combs, microneedling, to name a few. The latest trend is rosemary oil, with TikTok full of young men exhorting its powers. (Personally, I'm not minded to try it, on the basis that I don't want to smell like a roast potato.) Some of these treatments may do limited good for some people, but there is little scientific evidence that they slow or reverse balding. Those that do can have side effects and don't always work for everyone (see "Two drugs that help treat hair loss (well, a bit)", page 42).

Determined to make sense of it all, I visited hair and scalp expert Hugh Rushton at his clinic on London's Harley Street. He talked me through the basics of how hair loss works. First, you need to know that each hair goes through a growth cycle, growing for several years before taking a break for about three months and then falling out. About 10 to 15 per cent of hair is in this resting state at any one time. As male bodies age, healthy hairs can go through a process called miniaturisation, where they turn from regular "terminal hairs" into baby-fine "vellus hairs", which are almost invisible.

"Perhaps he could divine the secrets of skin moles to reverse baldness"

We have known for a while that the hormone dihydrotestosterone (DHT), which stimulates the development of male characteristics, plays a key role in this process. DHT prompts follicles to miniaturise, and if you can reduce it, balding can be slowed. Over the past few years, though, researchers have made spectacular progress in understanding the complex biology surrounding hair growth and loss and the many biological components involved.

It was cell biologist Karl Koehler at Harvard University who made a pivotal breakthrough around a decade ago. Back then, he and his team were trying to grow a type of cell found in the inner ear using stem cells. However, it turns out that these ear cells are closely related to skin cells, and the researchers found that they always got some patches of skin growing as a side product. At first, this was a pain. ›

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TWO DRUGS THAT HELP TREAT HAIR LOSS
(well, a bit)

Male pattern baldness happens when an enzyme called dihydrotestosterone (DHT) prompts hair follicles to give up the ghost (see main story). Finasteride, sold as Propecia, among other names, is a medicine that stops one of the body's ways of converting testosterone into DHT. It is most effective when taken in the early stages of balding. However, it has some side effects and only works for as long as it is being taken. It isn't effective for everybody, not least because the body has other ways of making DHT that can, for reasons not well understood, kick in for some people and not others. Finasteride can't be used to treat female pattern baldness.

Then there is minoxidil, sold as Rogaine, among other names. Exactly how it works isn't clear, but it is thought that it extends the natural hair growth cycle in men and women, so that you have more hairs growing on your head at any one time. Again, the results last only as long as the product is used and they can peak after a few months and then decline.

Thierry Henry. By age 50, 30 to 50 per cent of men experience pattern baldness

CHRISTOPHE SAIDI/SIPA/SHUTTERSTOCK

"It was this weed in our garden that we were trying to get rid of," says Koehler. Then they realised that these fragments of skin, if left to grow, would form two layers – the dermis and epidermis – and, eventually, even hair follicles. They had inadvertently created a skin organoid, with all its attendant parts.

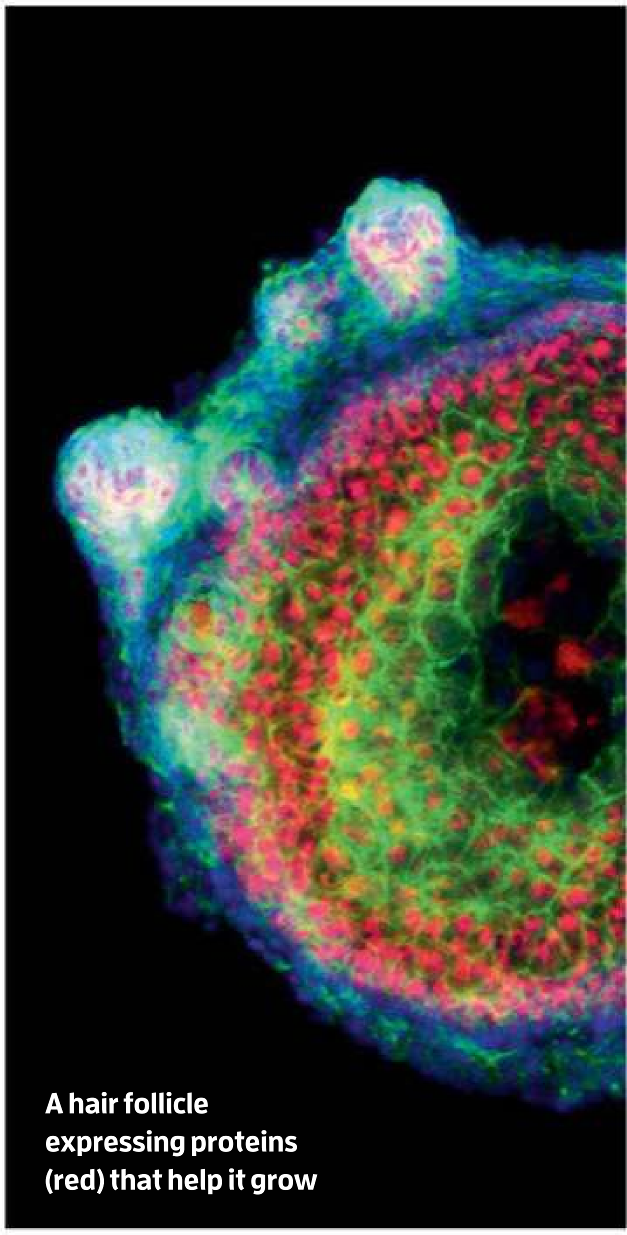
Koehler and his team refocused their efforts on culturing skin, tweaking the chemical recipe they fed the cells to steer them into the optimal pathway. In 2018, they published a paper demonstrating their success developing mouse skin, and in 2020, they repeated the feat with human skin.

It takes about 50 to 70 days to culture a stem cell into a small patch of skin with hair. The skin forms in a bulb-like shape, about 4 millimetres wide. Koehler says he has already grafted these bulbs onto the backs of mice, where the skin begins to grow hairs. The first application could be as a way to test drugs to treat skin conditions, he says. But it is tempting to wonder whether this could be a way of grafting hair onto a bald head.

Hair transplants already exist, of course, but they have drawbacks. Follicular unit extraction, or FUE, for instance, takes follicles from the sides and back of the head, where the hair is still growing, and transplants them onto a balding area. The trouble with FUE, aside from the cost, is that it merely redistributes hair so cannot transform an empty scalp into a luxuriant mane.

With Koehler's hairy skin organoids, we are talking about growing new hairs, which is quite the breakthrough. You could easily imagine it being used to reverse baldness. "We're definitely thinking about this," says Koehler. There will, however, be hurdles, like growing the skin larger and overcoming graft rejection – the skin would probably have to be grown from stem cells taken from the transplant recipient. "It's going to be hugely expensive and not fast – not on the timescale some balding men might like," says Koehler. But perhaps there is an easier option.

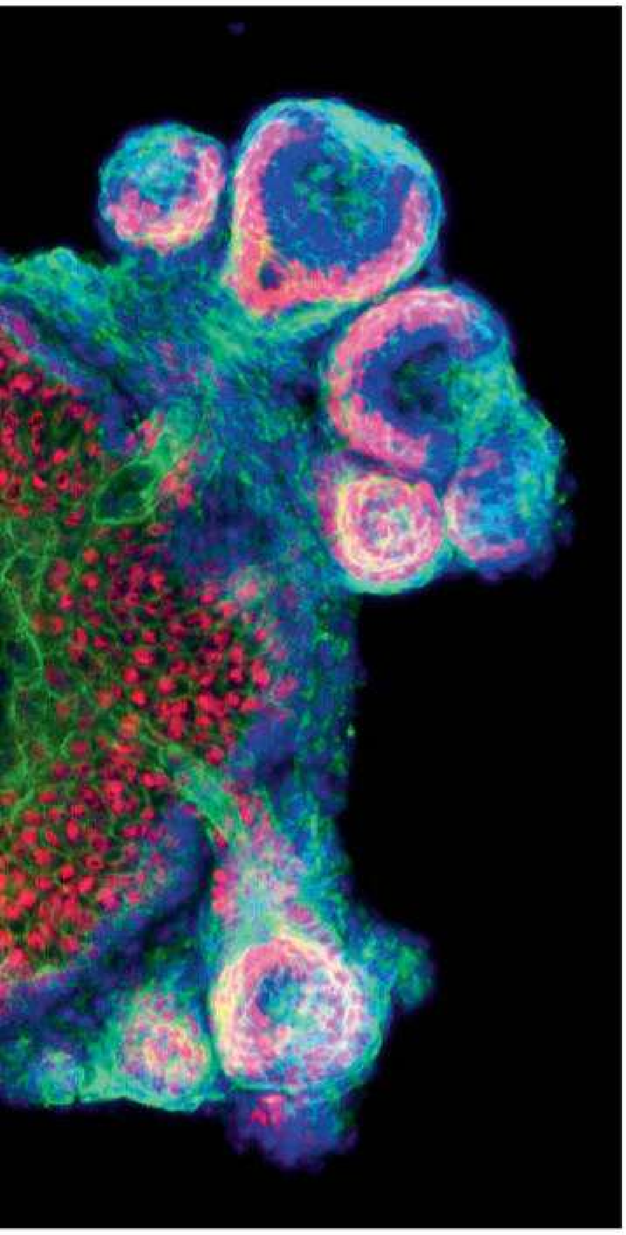
At the root of each hair there is a group of dermal papilla cells, which are involved in regulating hair growth. We know that in some hair follicles, such as those on the head, these crucial cells are lost with each successive hair growth cycle, until they are all gone. As a result, the signals telling hairs to grow cease and hairs miniaturise. So why not replace dermal papilla cells? That is what Colin Jahoda at Durham University, UK, thought several decades ago.


A hair follicle expressing proteins (red) that help it grow

He took these cells from the coat hair of mice and injected them into the rodents' ears, which have much finer hair. The ear hair quickly grew longer and thicker.

In the early 2000s, regenerative medicine entrepreneur Paul Kemp founded a company that investigated whether injection of dermal papilla cells into the human scalp could stimulate the growth of entirely new hairs. The researchers found that it worked, but the new hairs were thin. However, at the same time, they observed that thinning hairs got thicker. The treatment went through stage I and II clinical trials, which showed that it was safe. But then for reasons that are unclear, the line of research was dropped.

In 2015, Kemp founded HairClone to revive the work on dermal papilla cells. The plan was twofold. First, healthy dermal papilla cells would be extracted from young people and frozen in a follicle bank. Then, when those people began to thin on top, the cells would be cultured and injected back into the scalp. "The idea is that, as those cells are being lost, you're injecting them back in," says HairClone's head of research, Jennifer Dillon. Unlike the skin organoids, this treatment doesn't have the potential to restore hair to a person in an advanced stage of pattern baldness because it would only revive ageing follicles, not those that have already miniaturised.



JIYOON LEE AND KARL R. KOEHLER

> **"Young people can cryogenically freeze their follicles to avoid future hair loss"**

But it is a big deal because it could fix the problem of follicles dying off in the first place.

HairClone has already created a follicle banking service, where people can have some of their dermal papilla cells removed and cryogenically frozen. This service is available in the US, Canada, Australia and the UK. Meanwhile, Dillon is working on perfecting the process of multiplication.

Dillon says the procedure is popular among parents who want to bank their teenage sons' follicles, so that they may avoid the hair loss their fathers have experienced. But women are banking too. Jane (not her real name) from London experienced hair thinning after an infection in 2018 and later discovered that she had breast cancer. With the prospect of losing the rest due to chemotherapy, she decided to take out an "insurance policy" and bank 100 of her follicles. "I would be gutted if they invented some way to rejuvenate hair and I had not taken the opportunity to prepare for it," she says. The banking cost £2000 and she pays a yearly fee of £120 to keep her follicles on ice.

The next step is to show that the injection of cultured dermal papilla cells is safe and effective. HairClone is currently offering the treatment off label in the UK. The company can't make any claims about its efficacy, but can give it to people to collect data about the best treatment regimen ahead of clinical trials.

Maria Kasper, who studies the biology of skin and hair at the Karolinska Institute in Stockholm, Sweden, says she hasn't seen enough data to judge how efficiently it will work in balding human scalps. She also points out that each round of cloning tends to reduce the papilla cells' ability to induce hair growth, which could be a challenge. "But when it works," she says, "it would likely be a long-term solution", with the revitalised hair perhaps lasting decades.

Dermal papilla cells offer great promise, but perhaps we don't need to go to the trouble of growing them. Maybe we can replicate the chemical signals they whisper to hair instead. To do so, we need to know the nitty-gritty details of exactly what makes hair grow. "That is what the last decade and a half has provided," says Plikus.

All over the skin, there are epithelial stem cells that can go on to form other kinds of cell, including hair cells, depending on the chemical signals they receive. In theory, if you could hijack this cell signalling, you might produce a hair loss therapy. This is a fraught business, though. Two of the pathways known to enhance hair growth are called Wnt and hedgehog, so one idea would be to dial their activity up. However, their activity is also increased in many cancers.

You can think of these signalling pathways as a bit like a row of dominoes that splits off in many directions. Push over the first domino and you set off a messy, unstoppable chain reaction that might cause cancer. But Plikus reasoned that it might be possible to set off the reaction much further down the line, where the effects are more controllable.

He and his team began exploring this by genetically engineering mice in different ways so that their hedgehog signalling pathways were dialled up. One particular mouse looked promising, growing more hair than the others. By comparing all of the signalling molecules involved with those from non-engineered mice, they identified a protein called SCUBE3 that was boosted at a late stage in the hedgehog pathway. Investigations showed that this molecule is also switched on in human hair follicles at the start of a growth cycle.

Balding vaccine

Plikus says you could imagine SCUBE3 being injected into the scalp, or perhaps being administered as an mRNA therapy, where cells are given the instructions to make the protein, similar to how some covid-19 vaccines work. The first thing is to understand whether SCUBE3 would be safe as a drug. A spin-off company called Amplifica has now begun early-stage clinical trials to establish this.

But Plikus isn't done there. He has already produced another potential drug candidate, based on the bizarre fact that skin moles often encourage vellus hairs to turn thick and long. Perhaps, he thought, he could divine their secrets and use them to reverse baldness.

In June, he and his colleagues published work showing that a molecule called osteopontin was an important signal that drives the growth of these thick hairs in moles. "What's particularly exciting with this molecule is that nature has performed a natural experiment for us," says Plikus. Hairy moles appear on people with a wide variety of genetic make-ups, so we know that the effects of osteopontin aren't likely to be limited to a small group of people.

But the reason for optimism in this field isn't about any one treatment. Rather, it is that our burgeoning understanding of the signals that drive hair growth and loss suggests that there will be many ways of intervening in the process. That increases the odds of finding one strategy that works.

In my stronger moments, I tell myself I should shave all my hair off and be done with it – or just stop worrying about it. Then again, there is a wider perspective on all this. Most mammals have hair all over their bodies, but we humans lost the majority of ours aeons ago. In that context, maybe I can console myself with the notion that the hair on our heads is really just a remnant of a bygone age. ▮

Joshua Howgego is a features editor at *New Scientist*

Puzzles
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***Almost* the last word**
What would happen to a galaxy if its black hole left? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

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Standard deviations, plus AI goes down for the count p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

Debunking gardening myths

On home ground

The idea that native plants are better than "non-natives" has more to do with cultural bias than scientific evidence, says **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

I AM fascinated by how culture can colour our understanding of scientific reality, even when it comes to botany. Perhaps nowhere is this more the case than with the "native plants" debate in horticulture.

The prevailing idea is as follows: because some introduced, non-native species have caused major damage to ecosystems around the world, native plants are always a better choice for the environment. This belief has become an unquestioned part of much of popular horticultural wisdom. But where is the evidence?

In order to argue that native plants are always a superior choice, we would need to agree on a clear-cut definition of "nativeness" with objective criteria. In many geographically isolated parts of the world, such as the Galapagos, whose flora is so unique many species are found nowhere else, this may be easy to do. But does this apply somewhere like the UK, where I live? The answer is a pretty clear no.

As prehistoric glaciations have repeatedly wiped out much of UK flora, many plants seen today as invasive "non-natives" introduced by humans, such as the common rhododendron, grew here naturally in the relatively recent geological past. Conversely, many of our most cherished "native" plants, such as cornflowers (shown above), only arrived after being introduced by humans in the past few thousand years. The attempt to reconcile a scientific categorisation of "native" with cultural images of what is "traditional" has led most definitions of "native" to include all plants introduced to Britain more than 500 years ago.

CLARE GAINEY/ALAMY

Even if we did gloss over issues with this arbitrary definition, we would still need data that consistently showed "native" plants were always better at supporting other "native" species than "non-natives". Yet, while there is a wealth of science to show that a relatively tiny handful of "non-natives", such as Japanese knotweed, have devastated some environments, there are fewer studies that make broad, like-for-like comparisons with "natives" as a whole. And one of the most comprehensive of these found that, contrary to much accepted cultural opinion, "the best strategy for gardeners wanting to support pollinating insects in gardens is to plant a mix of flowering plants from different parts of the world".

This was because although "native" plants were more frequently visited at the beginning of the growing season, "exotics" remained in flower far later in the season, providing vital support for pollinators. Following the "native equals universally superior" ideology, according to this study, would be worse for pollinators.

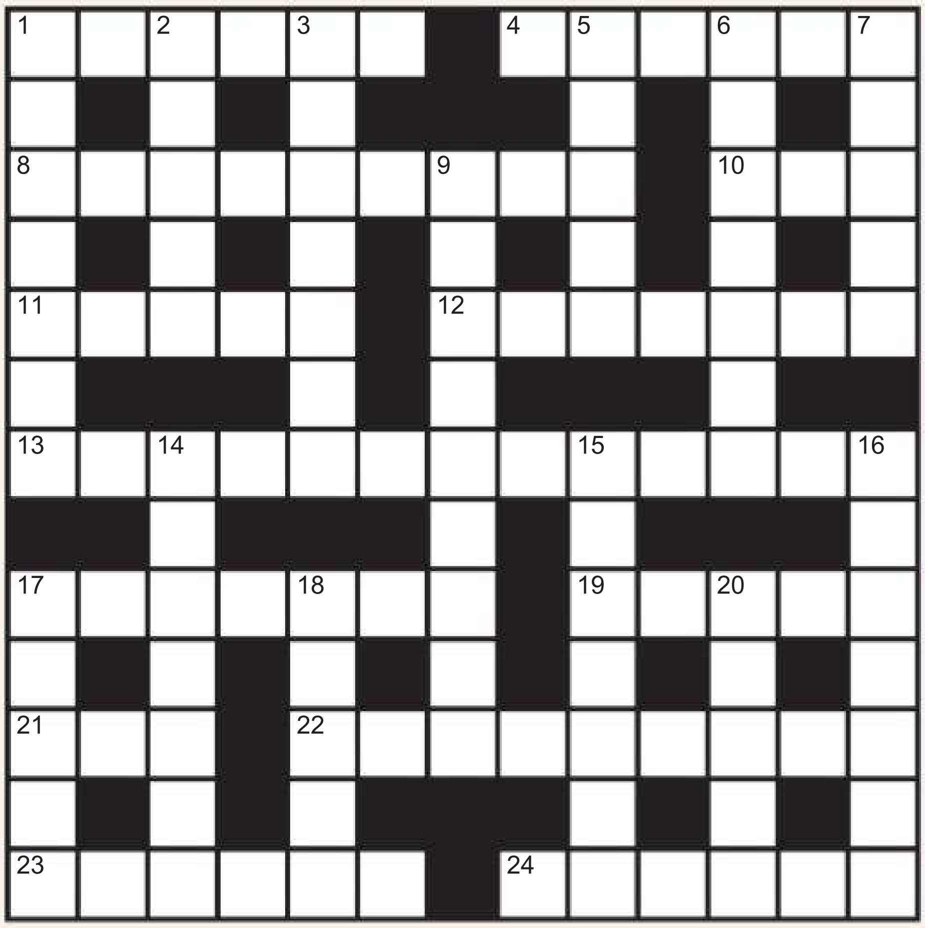
If we really care about the environment, we should also care about the evidence, which on this issue is far more complex and nuanced than is often discussed. ▮

Debunking gardening myths appears monthly

Next week
The science of cooking

These articles are posted each week at newscientist.com/maker

Cryptic crossword #119 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 German engineer passes English lake (6)
4 Underwater craft at lowest level brought back watery mass (6)
8 Drain soothing ointment covering pit viper's head (4,5)
10 Dash's partner returning to Denmark's capital (3)
11 Carefully manoeuvre large stand (5)
12 Intrude rudely, like a rookie (7)
13 Adolescents defending plot hole agitated zoomer? (9,4)
17 Disgusting to follow Facebook's leader in particular (7)
19 Uses gestures to communicate speaker's functions (5)
21 Leaves prof's helper taking drug (3)
22 Call about withdrawing additional endogenous chemical (9)
23 Hospital delivery doctor attacked nickname for small hominid (6)
24 Woodlouse, for instance, very stuck in outmoded music player (6)

DOWN

1 Closely analyse different sides at court (7)
2 Cambridge university's behind energy discharges (5)
3 Swallow jealous feeling, mostly, over Warsaw native on the rise (7)
5 Noble crushed nitre (5)
6 Spooner's declared, "Wait awhile next to the patient" (7)
7 Full blue coating stripped item (5)
9 Leo cut key, prepared cell (9)
14 Pair of librettists get close to second-rate script (6,1)
15 Posse ousted exhibits of bones (7)
16 Temporarily discontinue sulphur and uranium use (7)
17 Retrieve first of figures cut into metal (5)
18 Vehicle seizes up, missing turn at one resort location (5)
20 Classify fish without hesitation (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #221

set by Bethan Ackerley

1 The protein shell of a virus that encloses its genetic material is known as what?

2 In what year was the Doppler effect first proposed?

3 The cuneiform tablet Plimpton 322 hints that Babylonian cultures may have had knowledge of which mathematical principle?

4 Cholecystitis is inflammation of which organ?

5 Which cosmonaut flew in the Vostok 6 spacecraft in 1963?

Answers on page 47

Headscratcher

set by Rob Eastaway and Brian Hobbs

#241 Escape room

To celebrate the release of Headscratchers, *our book of* New Scientist *puzzles, there is no right answer for this week's puzzle. Instead, we want your creative solutions – mathematical, scientific, lateral or just eccentric. Credit will be given for imaginative use of all items in the room. Our three favourite answers will win a copy of our book, with the best printed in* New Scientist.

Prince Golightly dizzily opened his eyes. He was tied to a chair with a rope that seemed to be loose – he reckoned he could untie it. Looking around, he saw he was in a square room roughly 10 metres on each side, with four vicious monsters chained in each corner. They were currently sleeping – but get within a metre of one of them and he was finished.

There was a door in the centre of one wall, and he needed to reach it without waking the monsters. Close to him, a light dangled on a long cord from the middle of the ceiling. By his feet, he noticed a large dictionary, a roll of duct tape, a broom, a kitchen clock and a bucket of water with a russet fish swimming in it. Just then, the light bulb blew. Now it was totally dark, and he had no sense of direction. How could he escape?

Email your suggested solution to alison.flood@newscientist.com, subject: Headscratcher

Leaving space

What would happen to a galaxy should the black hole at its centre "leave" for whatever reason?

Herman D'Hondt
Sydney, Australia
In the short term, astronomically speaking, nothing much would happen. Without the black hole, there would only be some missing mass at the centre. Depending on the galaxy, this could be from 100,000 to a few billion solar masses. Galaxies have a total mass of between a billion and 30 trillion solar masses, so the missing amount would be a fraction of 1 per cent.

If the black hole vanished from the centre of our galaxy, the effects of its missing gravitation would travel outwards at the speed of light. Hence, the sun wouldn't feel any difference for about 26,000 years. As the sun's galactic orbit is determined by the bulk mass of our galaxy, and only to a small extent by its central black hole, at that time, it would experience a minute change in its orbit. Stars that were close to the black hole would, of course, alter their orbit more quickly and more violently. They might even be flung out of the galaxy altogether, as their orbital speed would be too high to be kept in check by the distributed mass of the galaxy.

> "Stars that were close to the black hole would alter their orbit more violently. They might even be flung out of the galaxy altogether"

Over the (very) long term, the fact that the galactic material would no longer be influenced by pressure waves when the black hole absorbed stars and nebulae might mean the formation of new stars was affected. So there might be fewer new stars in the galaxy. The Milky Way also couldn't become a quasar, a galaxy emitting powerful radiation, as this depends on the existence of a central black hole.

Peter Bubenzer
Parksville,
British Columbia, Canada
If the black hole suddenly "left" a spiral galaxy like ours – that is, it just vanished – then, while it is a very large mass, it would still be outweighed by the mass of the rest of the galaxy. The galaxy would continue to rotate, but the centre of rotation would be shifted to the centre of mass of the entire galaxy as determined after the removal of the black hole.

I assume the orbits of many suns would be affected, so there would be some upset (collisions, orbits shifted, stars and planets ejected from the galaxy etc.) until the new configuration reached some form of stability.

Of course, if the black hole "left" by taking a path out of the galaxy, rather than vanishing, that would also disrupt those parts of the galaxy it passed through, and take some parts with it.

Mark Thompson
Tewkesbury, Gloucestershire, UK
The Milky Way isn't dominated by the supermassive, destructive force of the Sagittarius A* black hole – it may have a mass equivalent to over 4 million suns, but the Milky Way contains billions of suns.

If Sagittarius A* donned its hat and went off to play, the surrounding stars might suddenly find themselves setting off in all directions due to a massive change in gravitational pull, but the rest of the galaxy wouldn't change.

In fact, for us earthlings approximately 30,000 light years away, we may see some of the aforementioned stars in new orbits, but we would be too far away for any gravitational changes (or radiation) to affect us.

For all we know, our black hole may have already gone, as the Vogons needed to build that hyperspace express route after all.

DASHA PETRENKO/SHUTTERSTOCK

Why do we screw up our faces and close our eyes when making an effort?

This week's new questions

Thinking hard **When we make an effort, why do we screw up our faces and close our eyes? This is of no apparent help and is likely to make us more vulnerable to predators.** ***Dorothy Woolley****, Newark on Trent, Nottinghamshire, UK*

Deep dive **Why don't marine mammals like whales get "the bends"?** ***David Garnett****, Rapid Creek, Northern Territory, Australia*

Seeing red

A piece of my pink-flowering geranium broke off when the pot fell over. We put it in a vase, where it made new flowers that were red, not pink. What is going on?

J. A. Crofts
Nottingham, UK
The plant is a zonal pelargonium, which is propagated by cuttings, rather than grown from seed.

The fact that the shoot broke off the main plant is irrelevant. The natural colour of the plant is bright scarlet from the pigment pelargonidin, but many new varieties are discovered as a result of genetic mutations, usually referred to as "sports". Some mutations occur as a result of a minor change to a single gene in a single cell in the plant causing a change in colour, and in this case, the mutation caused it to look pink. However, in a particular plant, it is quite common for the mutation to reverse itself, in which case a part of the plant shows the original colour (scarlet). This is known as a sectorial chimera, where both colours appear on different parts of the same plant.

This situation can be a confounded nuisance to plant nurseries propagating choice variegated or bi-colour shrubs, since many of these may be unstable and give rise to a proportion of plants that don't show the desired characteristics. A well-known example is golden privet producing green shoots.

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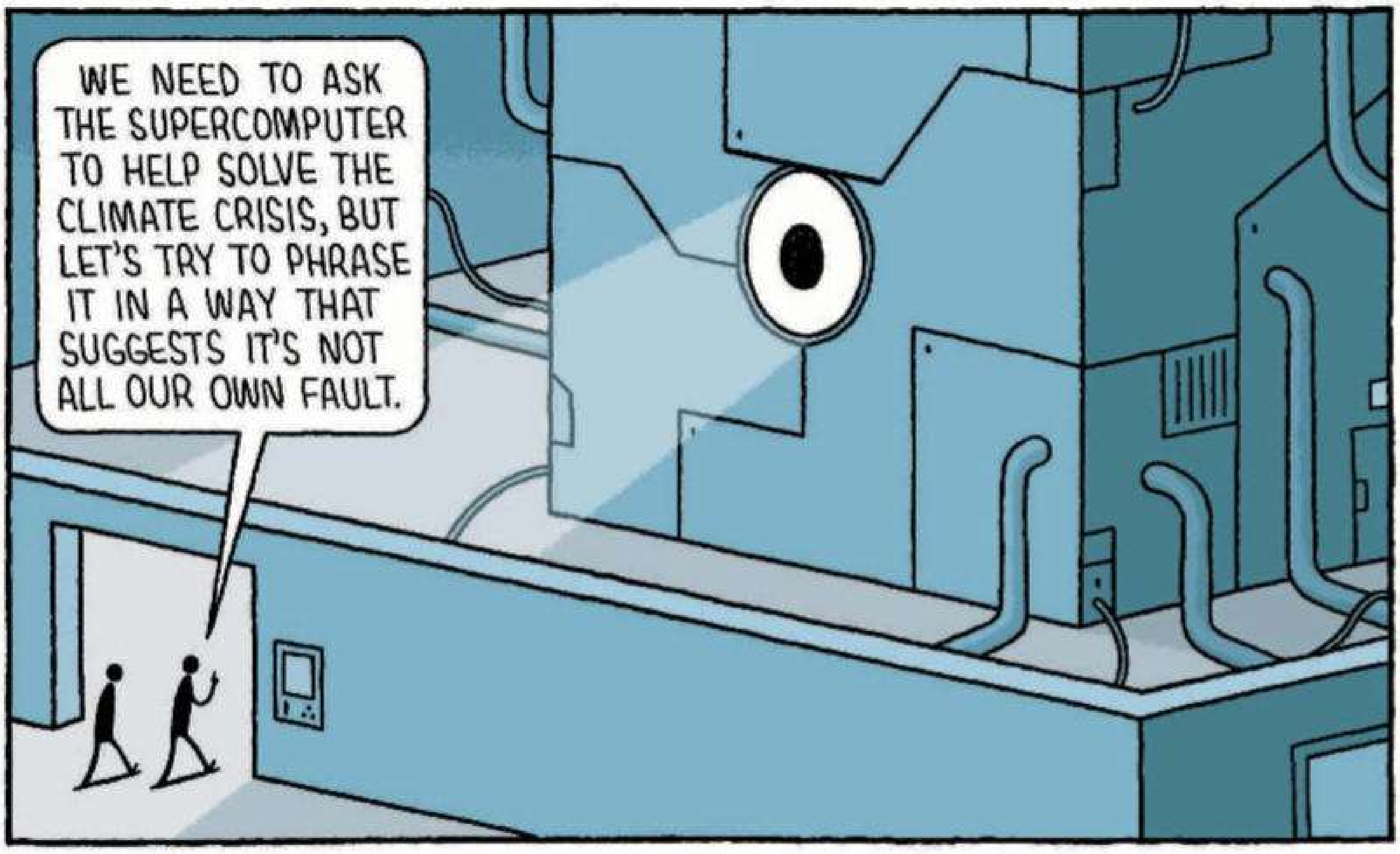
Tom Gauld
for New Scientist


WE NEED TO ASK THE SUPERCOMPUTER TO HELP SOLVE THE CLIMATE CRISIS, BUT LET'S TRY TO PHRASE IT IN A WAY THAT SUGGESTS IT'S NOT ALL OUR OWN FAULT.

David Muir
Edinburgh, UK
Many plants contain pH-sensitive coloured chemicals called anthocyanins. The colour of a hydrangea's flowers can be affected by changing the acidity, or pH, of the soil in which it grows. Lowering the pH by adding acidic matter to the soil will make the flowers blue. Adding lime, an alkaline substance, will raise the pH and turn the flowers pink.

The geranium that your correspondent Dot Graham wrote in about belongs to the genus *Pelargonium* and contains the anthocyanin pelargonidin, which changes from red in acidic solution to blue in alkaline solution. I would suggest the water in her vase was more acidic than the soil in which the geranium was growing.

Fun can be had with anthocyanins. If you boil or steam red cabbage, keep the leftover liquid. It contains the anthocyanin pigment that gives the cabbage its colour. Impress a small child with your wizardry by pouring the cabbage water into three glasses: one containing a little white vinegar, which turns the water red; one with a little baking soda, which turns it green; and one with a little water, which maintains the purple colour with which you started.

> **"The colour of a hydrangea's flowers can be affected by changing the acidity, or pH, of the soil in which it grows"**

For the love of rats

Given the huge ecological impact that domestic cats can have on their surroundings, why don't we domesticate more rats as our family pets, rather than vilifying them? (continued)

Josephine Dundas
Perth, Western Australia
If we are to give up cats as pets because of their ecological impact, I suggest that we give up dogs too for the same reason. Research shows that dogs walking in forests stress native animals, resulting in lower reproductivity and a host of other effects. A 2011 study of owners' observations of wildlife predation by their pets shows that similar numbers of animals are caught by both dogs and cats.

Blow or chill?

Driving in summer, I can cool my car by using air conditioning or opening the windows. One drains the battery, the other makes the car less aerodynamic. Which is more efficient? (continued)

Alan Coulson
Nairn, Highland, UK
Years ago, I visited New Orleans. I took a cab to my hotel and was amazed to find the vehicle had electrically operated windows, still a novelty in the UK at the time. As the weather was hot, I decided to press the button and open my window. The response from the cab driver was "for Pete's sake, close the window, my air conditioning can't cool the whole goddamn city". ▮

Answers

Quick quiz #221
Answers

1 The capsid
2 1842
3 The Pythagorean theorem
4 The gall bladder
5 Valentina Tereshkova, the first woman in space

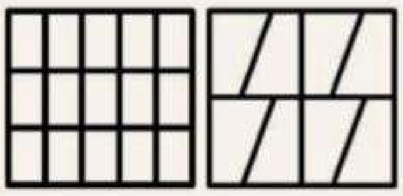
Quick crossword #142 *Answers*

ACROSS 1 Baby teeth, **6** Lymph, **9** Gestalt, **10** Paradox, **11** Younger, **12** Opening, **13** Grease gun, **15** Treen, **16** In two, **19** Postnatal, **22** Entropy, **23** Subsume, **25** Placebo, **26** At least, **27** Geeky, **28** Helvetica

DOWN 1 Buggy, **2** Bascule, **3** Tear gas, **4** Enter, **5** Hip joints, **6** Largest, **7** Midwife, **8** Hexagonal, **13** Guinea pig, **14** Gipsy moth, **17** Titrate, **18** Orogeny, **20** Nebulae, **21** Tsunami, **23** Small, **24** Extra

#240 Tango tiles
Solution

On the right is a way to do it with six congruent tiles. If you don't want to turn tiles over, it can be done with as few as 24 tiles, as shown on the left.



Double standards

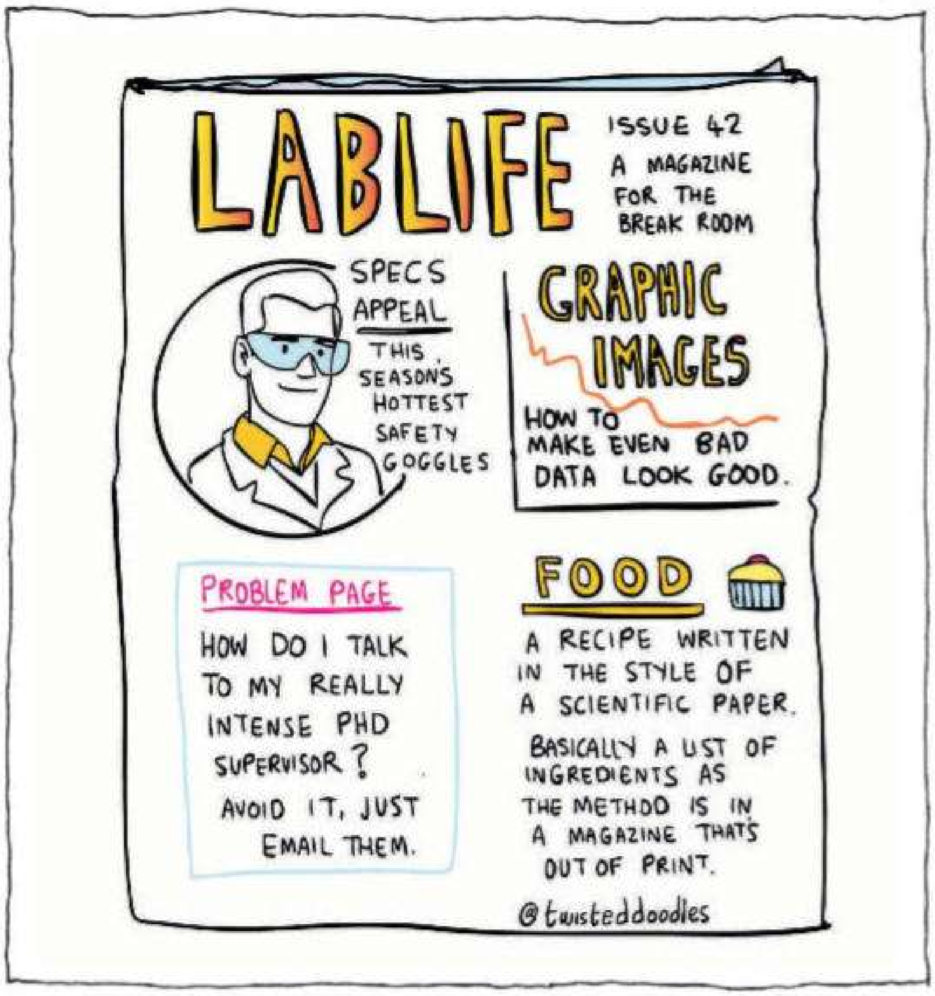
World Standards Day 2023 will arrive soon, two days after it arrives. As Feedback noted last year (17 September 2022), having double Standards Days is standard behaviour.

This year, most of the world will officially celebrate World Standards Day on 14 October. The date is specified by a consortium of three organisations: the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and the International Telecommunication Union (ITU).

The United States of America (which these days are less united than they used to be – except in celebrating World Standards Day) officially celebrates World Standards Day on 12 October. That date is specified by the American National Standards Institute (ANSI), an organisation long dogged by standards confusion. Two decades ago, *Occupational Hazards* magazine published this comment: "One area of confusion for safety professionals, design engineers, machine builders and users… revolves around the enforceability of [ANSI's] consensus standards."

The 2023 world celebration has an official slogan ("SHARED VISION FOR A BETTER WORLD"), an official poster, an official web banner, an official email signature, an official Zoom background and ever so much more. Lengthiest of all, there is a downloadable 20-page Visual Identity Guide, which specifies that logos for the special day "shall not be used in any way that could disparage the IEC, ISO and ITU brands, mislead users, create false impressions, or cause confusion".

Twisteddoodles *for New Scientist*


LABLIFE
ISSUE 42
A MAGAZINE FOR THE BREAK ROOM
SPECS APPEAL
THIS SEASON'S HOTTEST SAFETY GOGGLES
GRAPHIC IMAGES
HOW TO MAKE EVEN BAD DATA LOOK GOOD.
PROBLEM PAGE
HOW DO I TALK TO MY REALLY INTENSE PHD SUPERVISOR?
AVOID IT, JUST EMAIL THEM.
FOOD
A RECIPE WRITTEN IN THE STYLE OF A SCIENTIFIC PAPER.
BASICALLY A LIST OF INGREDIENTS AS THE METHOD IS IN A MAGAZINE THAT'S OUT OF PRINT.
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Not a job for AI

Anna Butcher – whose name looks like, but may not be, an example of nominative determinism – tells Feedback that attempts to use artificial intelligence to count sheep (Feedback, 29 July) are based on ignorance. Anna explains:

"We farmers can only shake our heads at what is to us a ludicrous idea of counting sheep with AI. Counting sheep accurately is quite a skill, a skill that many Australian livestock producers and stock agents have. Sheep aren't counted individually, but in twos or fives. It is usually done in the yards, not in the paddocks (fields), and is very well done – usually to the exact number even if the mob is in the hundreds! It takes a matter of minutes and I can assure you it is neither onerous or sleep inducing.

To count the hundreds, you put some small rocks in your pocket and transfer them to your hand. Counting of sheep in the field is far too onerous and inaccurate; the sheep may be resting under vegetation or hidden in a far corner of a paddock; if disturbed they don't stand still and may remain unaccounted for."

ANNA BUTCHER

Anna sent the photo you see to the left, of a countable number of Dorper ewes and lambs.

Laws of all kinds

For anyone who likes laws – laws of any and all kinds – the place to be in 2023 was the German National Academy of Sciences Leopoldina in Halle. On 28 and 29 September, people assembled there for an event called "Law(s): Rules of reality – rules for reality".

The "broad spectrum of laws of God and nature, rules and regularities is at the heart of this year's Annual Assembly of the German National Academy of Sciences Leopoldina", explains a press release. Among the touted topics: "rules and regularities in the natural, human and social sciences", "the concept of 'right' and "wrong' in mathematics", "the legalities of musical freedom" and "various religious laws".

Feedback savours one particular difference between scientific laws and judicial laws: what happens when a law gets broken.

When a behaviour – any behaviour at all – undeniably conflicts with a scientific law, scientists conclude that that law is wrong and needs correction. But when a behaviour undeniably conflicts with a judicial law, the judicial system concludes that that behaviour was wrong and needs correction. Public discussions, especially in courtrooms and political arenas, don't always make that distinction.

Inner (ear) harmony

Simon Leach explains how he uses a trivial superpower – of a kind recently added to Feedback's catalogue of trivial superpowers – to explore the arts. He says:

"After reading about Rob Holmes' trivial superpower of flexing his middle ear muscle (stapedius, the smallest muscle in the human body) [Feedback, 15 July], I realised that I have the same superpower. Further, by voluntary contractions, I can play a bass line in a tune. Only for my own consumption of course. I am currently playing the theme tune of *Thunderbirds*. I can also voluntarily open my Eustachian tubes, a boon when flying. I attribute my superpower to repeated episodes of otitis media when young." ▮

Marc Abrahams

Not sure what to see at New Scientist Live?

Here's what members of the *New Scientist* editorial team are most looking forward to

Alison Flood
Comment & culture editor

This is my first time at New Scientist Live and there's so much to choose from, but I'll definitely be at Claudia Hammond's talk on the science of kindness, in the hope of picking up some tips. I'm also looking forward to Lucy Cooke's myth-busting look at female animals. My kids will be coming along too and are very excited about seeing Maddie Moate in the flesh – *Maddie's Do You Know?* has been a staple in our house for years. They're also super keen on meeting Spot the robotic dog. And I have to mention Laline Paull, the brilliant author of our recent *New Scientist* Book Club pick *Pod*. This novel is told from the perspective of a dolphin, and she will be telling me about how she managed to imagine herself into the mind of a cetacean. Come and join us, and the book club while you're at it!

Sam Wong
Assistant news editor

I'm thrilled to be hosting the Our Planet Stage on Sunday, where we have a cracking line-up. Alice Roberts will no doubt draw a big crowd for her talk about the ancient people of Britain and what we can learn from their burials and DNA. I'm excited to hear Kit Franklin describing the future of food production, and how technology can reduce the environmental impact of farming. I'm also looking forward to Simon Sharpe's talk on how we need to rethink our response to climate change – hopefully some fresh ideas will leave us feeling inspired and optimistic.

Obomate Briggs
Video editor/Social video intern

This will be my first New Scientist Live in London and I've been looking forward to it ever since I started! There are so many amazing talks on offer, but I am particularly looking forward to the talks on the Future Stage and discovering how science will shape the coming decades. Having wanted to be a forensic scientist in a past life and working recently on a video project about artificial intelligence and forensic anthropology, I am excited to learn more from Niamh Nic Daeid about how cutting-edge technology can be used to investigate crime scenes.

Graham Lawton
Staff writer

I'd really like to see University of Cambridge psychologist Sander van der Linden's talk on psychological vaccines against misinformation – it's a topic close to my heart, having just written a feature on it. Unfortunately, I can't because I'll be on a different stage at the same time, interviewing Feargal Sharkey about his tireless campaign to clean up Britain's rivers. He is a fierce advocate for clean rivers as well as a musical hero. So, I'll have to watch Sander on catch-up after the show. But once I'm done with Feargal (I think he'll be doing most of the talking), I'll head over to the Universe Stage for Amy Smith and Mike Cook's talk on generative AI, which I really ought to know more about.

Leah Crane
Space & physics reporter

I'm travelling all the way from Chicago for New Scientist Live this year, and I absolutely can't wait. On Sunday, Chelsea Whyte and I are putting on the first-ever live episode of *New Scientist*'s newest podcast, *Dead Planets Society*, where we take our wildest ideas about how to tinker with the cosmos and invite expert scientists to put our flights of fancy under the scrutiny of real physics. In the live episode, we're going to try to make the worst possible world for life, and I couldn't be more excited. Ironically, I'm also hosting the Our Planet Stage on Monday, where we'll have some fascinating talks on the best planet for life (as far as we know). Plus, we'll be talking directly to an astronaut aboard the International Space Station.

Limited tickets remaining! Book today at
newscientist.com/pa0109

omegawatches.com

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Ω
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